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AN EXPERIMENTAL STUDY OF VORTEX MOTIONS IN LIQUIDS.

BY

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IT is not improbable that the first observer of vortex motions was Sir Walter Raleigh; if popular tradition may be credited regarding his use of tobacco, and probably few smokers since his day have failed to observe the curiously persistent forms of white rings of tobacco smoke which they delight to make. But some two hundred eighty years went by, after the romantic days of Raleigh and Sir Francis Drake, who made tobacco popular in England, before a scientific explanation of smoke rings was attempted.

About 1867 Professor P. G. Tait translated into English a most important mathematical paper by the German physicist Von Helmholtz. In this paper Helmholtz submitted to a rigid mathematical analysis the motions and the properties of vortices in an assumed perfect fluid, that is a fluid without viscosity. Tait's translation, which appeared in the Philosophical Magazine, immediately attracted the attention of Lord Kelvin, who saw in the results of the analysis of Helmholtz a possible explanation of the ultimate constitution of matter.

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Tait illustrated the several points of the Helmholtz argument by some cleverly devised experiments with smoke vortices. He provided a large cubical box with a round hole in one side and a flexible diaphragm on the opposite side. Ammonium chloride fumes were generated in the box to provide the smoke. When the flexible side of the box was struck sharp blows, symmetrical and swiftly moving rings issued from the hole opposite. These possessed many of the curious properties which Helmholtz had predicted for the vortices in a perfect fluid. They had integrity of form and moved swiftly forward always in a line normal to their plane, and carried with them the same material with which they issued from the box. They seemingly possessed elasticity of form such that striking slanting-wise an object or another ring, they were thrown into violent vibrations, as if they had been hollow anchor rings of rubber or similar material. If a swiftly moving ring was made to follow close behind a more slowly moving one, the forward ring was overtaken and this, as the other approached from behind, would accommodatingly expand and allow the approaching ring to pass through it. The ring now in advance would then be overtaken by the first ring and in turn would expand to allow this to overtake and pass through it, the speed of the approaching ring having been increased by an apparent attraction, as between the rings.

These experiments were witnessed by Lord Kelvin who was deeply interested, and the ideas suggested he rapidly developed into his famous vortex theory of matter, in which the ultimate particles of matter are postulated as consisting of indestructible vortices in the ether. Essential to this theory is the supposition that a vortex filament of circular or other form, knotted or interlinked with another filament, would, if once created in a perfect fluid, endure forever. It might vibrate, encounter obstacles, expand or contract, but it could not be cut or broken into parts. Motion, whirling, rotary motion, about an axis or line closed upon itself, was the essence of its entity. According to Kelvin, one portion of space contains matter, if the ether in that space possesses vortex motion, while another portion of space is without matter if the ether in that space is not possessed of vortex motion. The atoms are vortices and are eternal.

In the many scientific memoirs which Kelvin wrote during this period, this novel view of a kinetic constitution of matter was supported with consummate skill.

It seems strange, however, that though the laws of vortex motion were exhaustively examined by the ablest mathematicians of the time, few if any experiments were made to study vortex motions in air and fluids, beyond the first experiments with smoke rings above referred to.

Finally with the discovery of radium the entire scientific world, including Kelvin himself, adopted the more fruitful ideas regarding the constitution of matter, which have become crystallized in the modern "electron theory."

That few experiments were tried appears the more astonishing, when it is considered that we have at our disposal such high density fluids as water and oils with free surfaces and small viscosity, in which beautiful vortex motions may be easily produced in great variety and of curious forms.

The experiments which are about to be described would, if made earlier, have possibly had a greater interest as bearing upon Lord Kelvin's ingenious theory of the vortex atom.

However, consider the electron which modern theory substitutes for the vortex atom. Calling it an elemental unit negative charge of electricity is but giving a name to something whose ultimate nature is as obscure as the hard atom of Lucretius made somewhat more thinkable by the Kelvin hypothesis.

The first crude experiments were of a kind such as to be reproducible with slight effort and little or no expense. In the center of the cover of a baking-powder tin a round hole, about 1 cm. in diameter is made. This is filled with water colored with red or black ink and covered. Care must be used to fill the tin completely so that no air remains. A porcelain bath-tub makes a most convenient water tank. This is filled nearly full and the tin, with its colored water, is submerged at one end of the tub. The tin is held horizontally in the left hand while a sharp blow is struck by means of a hammer in the right. A perfectly symmetrical vortex ring, somewhat greater in diameter than the hole in the tin, will be expelled and travel to the far end of the tub, reaching it in about a second. This production of visible rings may be repeated until the water in the tub becomes clouded with ink.

Two interesting properties of these rings may be tested at once. If the tin is held so that the ring grazes the side of the tub, it is, on touching the side, broken up and scattered, but if it be pointed so that the ring goes, not at too great an angle,

toward the surface of the water, it is, on reaching or nearly reaching the surface of the water, reflected down from the surface. The angle of reflection is equal to the angle of incidence, and the ring preserves both its form and velocity. The plane of the ring always maintains itself perpendicular to its direction of motion, hence when reflection occurs the ring tilts its plane through an angle.

The experiments first made in this way seemed to promise a line of interesting investigation, if properly constructed apparatus was made and methods devised for the production of the rings under conditions that could be completely controlled and modified in various ways.

It was decided to construct a suitable outfit for making a series of qualitative observations of the properties of the rings and then, if it should prove possible, to take instantaneous photographs of them. Both plans were executed successfully and the outfit and methods employed will now be described in sufficient detail so that any one, who wishes to reproduce the apparatus and experiments and take photographs, may do so.

DESCRIPTION OF APPARATUS FOR PRODUCING LIQUID VORTICES.

It was recognized at once that a tank was required which would permit the rings to be observed from the side, the top, and the end. Furthermore, for continuous experimenting, the rings must be colored with a material which, when the rings break up, would entirely disappear and leave the water of the tank clear, for otherwise the tank would require repeated refilling.

Fig. 1 shows clearly the construction and dimensions of the tank used. The bottom and ends were of wood and the sides of clear plate glass 7 mm. thick. Its inside dimensions were—length 151 cms., height 60 cms., and width between inside surfaces of the plate glass 12 cms. In one end was mounted a lens 10 cms. in diameter, through which one could see with a clear focus almost to the far end of the tank when it was filled with water. In the end opposite to the lens, close to the bottom, there was a spigot for emptying the tank. The pressure of the liquid against the glass sides made them bulge out dangerously and removable brass straps were required to hold them together at the top.

The method of shooting the rings and the construction of

the "gun" received much consideration, and after two years' experience with the first form constructed, no single detail seems to need change. An electro-magnet was used to produce the impacts upon the flexible metal diaphragm of the gun. The choice of an electro-magnet proved, later on, to be a wise one when the rings were being photographed, as the timing and force of the blow could be precisely regulated.

FIG. 1.

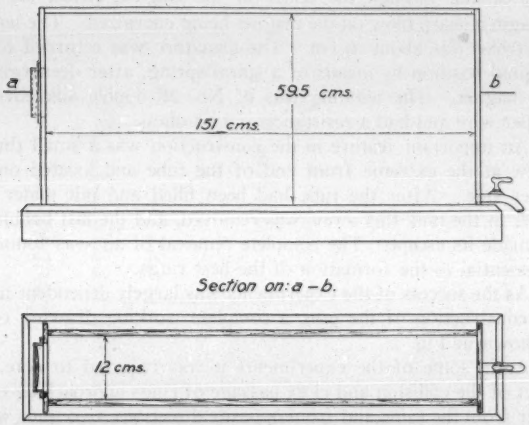


Diagram of tank.

The gun was supported on brass rods in such a manner that it could be aimed in any desired direction by adjustments made above the water. The hole in the front end of the gun from which the rings issue could be closed or opened by means of a hinged metal piece which also was operated by a brass rod above the water. The gun proper consisted of a short cylindrical brass tube 7.7 cms. in diameter and 6.6 cms. long. On the front end of this tube was a removable disk of brass held in place against a shoulder with thumb screws. Disks were provided with holes of various shapes and sizes, and some with more than one hole. The flexible diaphragm in the back end of the tube was of phosphor bronze, well hammered to be springy.

The electro-magnet, for producing the impact upon this diaphragm was in the form of a split hollow anchor ring and of the same diameter as the tube. The armature was on the side opposite the tube and consisted of a disc of soft iron with six radiating fingers. The winding lay in the hollow of the anchor ring and was embedded in wax. Access of water to the winding was further prevented by covering the open end with thin sheet brass. A rod was fixed to the centre of the armature normal to its face and, passing through the centre of the magnet, struck the diaphragm a sharp blow on the magnet being energized. The length of stroke was about .6 cm. The armature was returned to its original position by means of a spiral spring, after deenergizing the magnet. The winding was of No. 28 double silk covered copper wire and had a resistance of 17.5 ohms.

An important feature in the construction was a small thumb screw at the extreme front end of the tube and located on its upper side. After the tube had been filled and put under the water in the tank this screw was removed, and the last bubble of air made its escape. The complete removal of air was found to be essential to the formation of the best rings.

As the success of the experiments was largely dependent upon the construction of the gun, a complete working drawing of it is shown in Fig. 2.

As in some of the experiments it was required to note the effect of the collision and close passage of rings approaching each other from the same and from opposite directions, two guns were constructed. When their magnets were joined in series, rings could be ejected from the two guns at the same instant.

The entire apparatus including that employed for photographing the rings, is shown in Fig. No. 3 reproduced from a photograph.

The gun was operated from a source of direct current of 110 volts. As the circuit through the gun magnet could be closed only for an instant, a switch was devised so that by pulling a trigger the circuit could be made and quickly broken again. As this switch may be of use in other connections where a circuit carries a large current for a brief time, and as it is simple in construction it is shown in Fig. 4.

The rod of metal, bent down at each end and supported at its middle point on a fulcrum, has one end in a cup of mercury

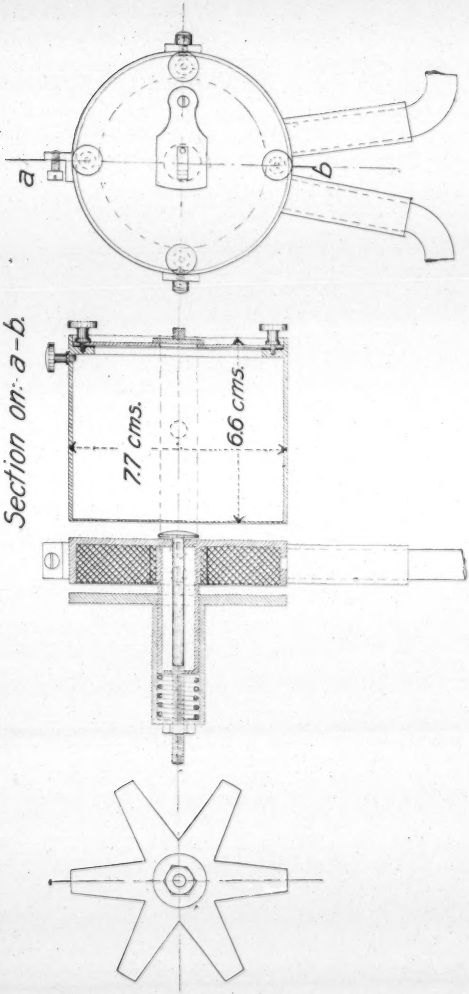


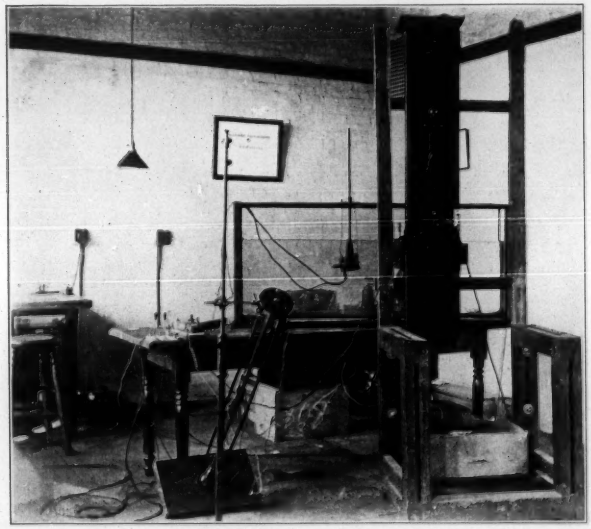
FIG. 2.

Working drawing of gun.

while in its initial position, and the other end in another cup of mercury when in its final position, to which it is drawn by a spring when a catch is released. Only when the rod is horizontal is each end in a mercury cup, thus closing the circuit from mercury cup to mercury cup.

This switch, together with a rheostat, was used in circuit with the gun and 110 volts. As the gun is under water a current of

FIG. 3.



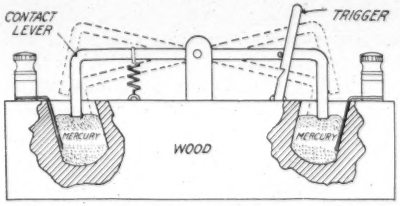
Photograph of outfit.

10 or more amperes could be passed through the winding for a brief time without overheating. The plunger could, therefore, be made to give a very hard blow upon the flexible diaphragm and eject a ring at high velocity, and possessing considerable energy.

The problem of making deeply colored rings, which could be easily observed or photographed, but which on breaking up would leave the water perfectly clear, was successfully solved for rings of a deep red color and of a milk white color. For the

red rings phenol phthaline was used. This substance is, as purchased, a white powder. To prepare it for use, a teaspoonful is dissolved in ethyl alcohol, just enough being used to dissolve it. This solution is then diluted with about two litres of pure water. It is then colorless or slightly milky in appearance. About a tablespoonful of strong ammonia is then added which turns the solution to a deep, rich red color. This is put in the gun. To the water of the tank, while it is being filled, to get good mixing, is added about an ounce of strong hydrochloric acid. The gun is placed in position in the tank and the last bubble of air is allowed to escape. The connections of the electric circuits are then made, when the apparatus is ready for shooting rings.

FIG. 4.



Gun switch.

A ring when shot goes the length of the tank and preserves its form and color until it strikes the glass or end of the tank. When the ring breaks up the acidity of the water entirely destroys the red coloring matter of the ring, leaving the water of the tank perfectly clear, even after a hundred or more rings have been ejected. It was customary to refill the gun, however, after shooting about twenty-five rings, as they gradually grow paler.

For making milk white rings an emulsion of chloride of silver was used which also becomes colorless in a weak solution of ammonia. To make such an emulsion, which will not settle even after standing over night, a tablespoonful of clear gelatine should be boiled in a litre of water until completely dissolved; then mix with this about 15 grams of silver nitrate crystals, which have been previously dissolved in water. Then add a weak solution of hydrochloric acid, stirring well, until the nitrate is all precipitated as chloride. Care should be observed not to use an excess

of acid. The result is a smooth, milk white solution which will not settle, and will turn quite colorless in very weak ammonia water. This solution can be half diluted with water. The tank should be filled with weak ammonia water and the gun with the solution. Beautiful milk white rings can then be made in the same manner and with the same ease as red rings, and a large number may be shot without any clouding of the tank water.

SIMPLE QUALITATIVE EXPERIMENTS.

By means of the brass rod which supports the gun, and the rod which tilts it in a vertical plane, it may be quite accurately pointed in any desired direction. By applying 110 volts directly to the magnet, the ring which issues from the gun will go the entire length of the tank in about one-half second, and the gun may be aimed so that it will hit the lens at the far end of the tank fairly in the centre. When the ring is near the lens it begins to expand, and will increase, at the moment of striking, to several times its original diameter. The ring is best observed end on through the lens as it approaches. It is seen to be about 1.9 cms. in diameter, or 1.5 times the diameter of the hole in the tube. Its form is quite symmetrical and resembles a small anchor-ring. The diameter of the solid portion is about 3.1 mm. and the hole in the center is between 12 and 13 mm. When observed through the glass at the side, the path of its motion is seen to be straight and its velocity gradually diminishes as its distance from the gun increases.

It should be particularly observed that the same material, the colored water which leaves the gun, moves bodily from one end of the tank to the other. It is thus possible to project for a distance of over a meter rings of a strong alkaline solution through a solution strongly acid. If the water of the tank contains suspended particles of slightly greater density than water, the ring will pass through and among them without incorporating and carrying them along with it. Thus sifting Indian meal into the water in the path of the ring it was found that none of the particles of the meal were taken up by the rings.

Another pretty experiment in this connection is to hold in the path of the ring chiffon cloth stretched over a frame when it will be found that the ring passes easily through it without being broken up or disturbed in its motion.

The kinetic energy of these rings is considerable. If a piece of tissue paper similarly stretched, be held in the path of the ring, the ring will break through it, but in turn is broken up by the impact. If a light watch-chain hangs in the water, and is fairly struck by a ring, it is bent into a decided curve by the force of the blow. This power of the ring to bend a chain was used to advantage in some of the later photographic work when timing the ring and the drop of a photographic plate.

If a gun is placed at each end of the tank and two rings are shot simultaneously in opposite directions it is observed that, if they meet fairly, both are broken up and dissipated; but, if their line of approach is such that they might be expected to touch on their edges on coming near together, they bend out of a straight course and pass without an encounter or injury to their form.

The swiftly moving rings described above may have their speed reduced as much as desired by inserting resistance in the gun circuit. The slowly moving rings are easier to observe and may be quite as perfect in form as the more rapidly moving ones, and for many experiments it is better to make slow rings, but as they move with less contained energy the phenomena of impact, deviation from the straight path, when approaching one another, and the vibratory phenomena are less marked and less well defined.

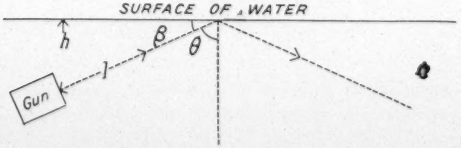
When the gun is tilted so as to shoot a ring toward the surface of the water it is, on reaching the surface, reflected in a very beautiful manner. As the surface of the water is approached the upper edge of the ring gains a little in velocity over the lower edge, so that the plane of the ring tilts through an angle, equal to the change in direction of the line of approach to the surface. In other words, the plane of a moving vortex ring is always maintained normal to its direction of motion. As near as could be judged from observations, the laws of reflection are the same as those of light rays. It sometimes happens that a ring approaches the surface of the water when this is disturbed by a wave motion and is not level. Under such circumstances the angle of reflection may appear quite different than the angle of incidence—but this is probably due to the indeterminateness of the latter angle. There is a certain critical angle which the line of approach of the ring to the surface makes with the normal to the surface of the water, at which

the ring will not reflect but jump out of the water with a spurt. The results of four carefully made trials to determine the value of this critical angle are given in the subjoined table. The diagram, Fig. 5, accompanying the table makes clear the meaning of the symbols used. We have, $\sin \beta = \frac{h}{l}$, hence $\beta = \sin^{-1} \frac{h}{l}$.

Trial	h cms	l cms	sin β	β	θ
1	16.2	44.5	.364	21°, 21′	68°, 39′
2	30.3	78.3	.387	22°, 50′	67°, 10′
3	34.2	82	.417	24°, 40′	65°, 20′
4	9.3	25	.372	21°, 50′	68°, 10′

It is possible to produce refraction of the rings as well as reflection. To accomplish this the tank is half filled with water and then with a rubber hose a dense solution of salt or barium-chloride is carefully siphoned into the tank at the bottom so as to make a layer of liquid denser than water underneath the water.

FIG. 5.



If a high velocity ring be now shot so as to pass at a slight angle from the water into the denser salt solution below, it will be observed to pursue a path which is slightly curved downwards. This experiment was not tried out as carefully as could be desired, but it seems certain that the path of the ring is considerably deflected in passing through media of different densities. It is probable, though no exact measurements were made, that the velocity of the ring diminishes when it passes from the lighter to the denser medium.

Rings which are ejected from a very exactly circular hole are always round and advance through the water with no other visible motion than that of progression. If, however, the hole in the gun is elliptical, vortices are formed and progress as before,

but they assume, in addition to their forward motion, a vibratory motion. The vibrations are such that the vortex changes from an ellipse with its major axis vertical to an ellipse with this axis horizontal. The vibrations are almost too rapid to be followed distinctly with the eye. It is a most interesting sight to observe such a vibrating ring as it moves throughout the entire length of the tank, especially if it is observed through the lens along its line of motion.

Triangular and square holes also give rise to vibratory rings. But the most remarkable property of water rings is observed when the end of the gun is provided with two holes, one above the other. In the experiments tried the two holes were each .85 cm. in diameter with 2.55 cms. between their centres. The two rings, which issue simultaneously from the two holes, begin to attract each other as soon as they leave the gun, and at a distance of about 6 to 8 cms. from the gun they come together with great suddenness and form a single ring of twice the circumference of one of them. The ring so formed proceeds with apparently the same velocity as a single ring to the end of the tank. It has, however, vibratory motions that are remarkable. Unlike the single ring, which issues from an elliptical hole and vibrates in one plane only, the ring formed by the union of two rings has a much more complicated vibratory motion in planes normal, and parallel to the direction of forward motion of the ring. The peculiarity of this motion will be better understood from references to illustrations given later. These vibratory rings will also reflect from the surface of the liquid but it is doubtful if the angle of reflection is equal, always, to the angle of incidence, as the angle of reflection will depend upon the phase of the vibration of the ring at the moment when it reaches the surface.

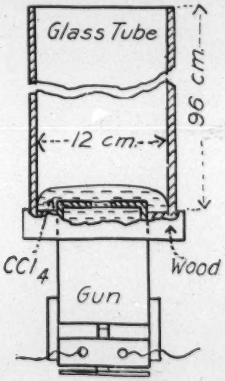
Novel and unexpected results were obtained when the surface of the water in the tank was covered with a layer of kerosene oil from 5 to 10 cms. deep. To render more apparent any phenomena which might happen the oil was given a deep red color. It may not be generally known that all ordinary dyes and coloring materials will not dissolve in oils but sink to the bottom without imparting to the oil any color. At least 20 or 30 coloring stuffs, including many aniline dyes, were tried before one was found which would impart a color to kerosene oil. Of those tried, two only were found which would color kerosene. One is known as alkanet root and the other is a coloring material

known under the trade name of Soudan III. Both materials were tried but the latter is the more satisfactory and imparts to the oil a deep rich red color. It will also color carbon-tetrachloride, acetone, paraffin, all oils and probably many other chemicals, but is entirely without effect on water. A thimbleful of this dye was used to color two or more gallons of kerosene, which was then floated upon the surface of the water in the tank. The gun was located about 30 cms. below the oil and aimed so as to project rings toward the surface of the oil at an angle, adjusted by trial, so that the water-ring would enter the oil. The result was surprising. The water-ring on entering the oil instantly became converted into an oil ring. This oil ring continued to move to the upper surface of the oil, where it was reflected, and moving downward entered the water as an oil ring and continued to move until broken up by its encounter with the end of the tank. The results were, of course, just the same whether the water in the gun was, or was not, colored. With no coloring matter in the water the vortex ring of water was invisible as it approached the oil, and the illusion was given of red oil rings issuing from the oil without any apparent agency for their production. After the ring broke up, the oil of the ring rose to the surface of the water and united with the main body of the oil, and this process could be continued indefinitely. It was, however, necessary to wait about a quarter of a minute between the shooting of successive rings as the surface of separation between the water and the oil required such time to regain its quiet and smoothness, after the agitation caused by the passage of a ring through the surface. It was found that to obtain oil rings in the above manner the angle at which the water rings were projected toward the oil had to be adjusted within rather narrow limits. This adjustment could easily be made, however, after a few trials. If an oil ring was projected with such a velocity that it nearly lost its forward motion before striking the end of the tank, the oil constituting the ring would segregate into small globules. The small globules would continue for a time in rapid circulation about the vortex filament. This rapid movement, in small circles, of the oil globules, in apparent defiance of centrifugal force, was a very striking and interesting phenomenon.

It was thought that in the case of two liquids of different densities, at least if these two liquids were not miscible, it ought

to be possible to project a vortex ring of the less dense liquid through the liquid of greater density, as kerosene oil through water; but that it would not be possible to project a vortex ring of the liquid of greater density through liquid of less density, as a water ring through kerosene oil. Such was proved experimentally to be the case. If the gun was filled with kerosene oil, the ring was easily sent the entire length of the tank through water. To test the reverse case a cylindrical glass tube was provided 96 cms. long and 12 cms. in inside diameter. This tube was placed vertically and the gun fastened in its lower end. The particular arrangement employed is shown in Fig. 6.

FIG. 6.



Assuming the reverse to be true, if the gun projected a vortex ring of the denser fluid through the water, the ring should rise to the surface of the water, there break up, and the material of the ring settle down and again join the supply in the gun. Hence the vortex rings might be continually projected up the tube without renewal of the liquid. But unfortunately this was found not to be possible. The denser liquid employed was a mixture of carbon tetrachloride and kerosene oil. This mixture could be given any desired density, slightly less to slightly more than that of water, by varying the relative proportions of the two liquids. The mixture was colored red with Soudan III.

What occurred was this: if the blow on the diaphragm of the gun was light, the red liquid would issue from the hole a short distance as a large, shapeless globule, which, after rising a short distance, would sink back and rejoin the liquid in the gun. If the blow was hard, the liquid would leave the gun apparently starting in the form of a ring but would fly to pieces after going but a few centimeters. The results appear to be the same however the density of the red liquid be varied, so long as the density is at all greater than the water. It was thus conclusively proved that where two liquids are non-miscible, a vortex ring of the denser liquid is unstable in the lighter liquid and can not be projected and preserve its integrity.

To determine whether vortex rings might be made to solidify and to produce solid rings, so to speak, a large earthenware jar was filled to the middle with cold water and from the middle to the top with hot water. The gun was filled with melted paraffin and held in the hot water and pointed vertically downward. In this way liquid rings of hot paraffin were projected through the hot water into the cold water. Upon entering the latter, they at once solidified and preserved their form. In this manner a number of solid paraffin rings were obtained. For the sake of variety the paraffin was in some cases colored red with Soudan III. These rings were quite symmetrical and made very pretty objects.

Numerous modifications were made of the orifice in the gun, from which the rings issued, with a view of finding the most efficient form for the projection of circular rings. In one modification a short tube was inserted in the end of the gun, but it was found that the best and most perfect rings could be obtained from a simple, circular hole in the centre of the front end of the gun. It appeared to make no difference whether the edges of this hole were sharp or not.

It soon became apparent, from these preliminary experiments, that, if the peculiarities of these rings were to be described to others, and, if what happened was to be precisely determined when the rings formed and especially when two rings united, it would be necessary to take photographs of them.

(To be concluded)

MACHINE MOLDING.*

BY

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THE art of molding is probably as old as civilization, and it may have reached a high state of development before any of the events which make up ancient history took place. In fact the molders' skill, as exemplified in many antique works of art, has been one of the great civilizing forces of the world, and it may be questioned whether we can produce to-day any finer examples of this art than are to be found among the relics of antiquity. But as civilization has progressed the demand for the products of the foundry has increased to such an extent as to call for new processes, better methods, and greater efficiency. The printing press, the steam engine, the loom, and, more recently, the internal combustion engine, have stimulated the activities of men, augmented their productive capacities and so enlarged the possibilities for commercial intercourse that it is difficult to realize how few of the comforts of life now enjoyed by the masses were within reach of the well-to-do or even the wealthy members of society as it was constituted two hundred or even one hundred years ago. George Washington, for example, began his career as a surveyor; carried with him the bare necessities of life, often slept out of doors on a bed of hay or straw, swam the streams that were too deep to ford, and later on, after enduring innumerable privations and hardships in many hard fought campaigns, laid the foundation for the government which stands as a monument to his sagacity, courage, and determination. There were no Pullman cars for him and no potentate, however great or wealthy, could have travelled a hundred years ago with the luxurious ease now within the reach of very moderate means.

Going back a little further to Columbus, in the height of his glory as the first admiral of what was then the greatest power

* Presented at the meeting of the Mechanical and Engineering Section, held Thursday, May 18, 1911.

in the world, we can imagine his quarters on a flagship which was but little if any better in size and comfort than the lifeboat of a modern steamer. In short, since man first began to utilize the forces of nature, so abundantly provided for his material comfort and enjoyment, the productive capacity of the world has increased at a rate which staggers the mind to follow and reduces to nothingness the spells wrought by Aladdin and his wonderful lamp.

To compare the industrial progress made since the discovery of America with all that went before would be a hopeless task, but it is not hard to believe that the nineteenth century alone surpassed in the development of the arts and sciences all that was inherited from the past and that in all probability the twentieth century will do the same. The present rate of industrial progress is indeed so rapid as to almost defy pursuit, and it is only possible to keep in touch with it in spots where our own special interests are involved.

No man nor set of men can grasp the enormous accumulation of knowledge bound up with advancing civilization, and as fast as the work of yesterday can be recorded the achievements of today are almost out of sight. This cannot go on forever at undiminished speed, and it is clearly due to the awakening of man to a knowledge of the natural forces within his grasp. It is accompanied at the same time by the destruction of the resources upon which it feeds and grows, and it will sooner or later be followed by a reaction when posterity begins to descend the slope leading back to the ashes from which so much greatness and power has been derived. A great deal of permanent value will no doubt remain, but with the prospect of exhausted resources before us, however distant that time may be, we may well pause for a moment to consider not only the conservation of natural resources, but also the efficiency of human labor upon which the conversion of our resources into wealth depends. We cannot eat our cake and have it, but we can make it last a long time and enjoy it with more satisfaction if we do not bolt it all at once

But the conquest of nature is not to be halted by sentimental considerations and the consumption of our resources will no doubt go on unabated until their conservation becomes a crying need. Its consideration now as a matter of national importance is one of the most hopeful signs of the times, and, fortunately

for all of us, efficiency as well as economy in all the affairs of life is coming into the foreground and receiving more attention than it ever has before.

People are beginning to realize that the high cost of living is due chiefly to extravagance and waste, and that there is such a thing as scientific management by which human labor may be conserved and its products enormously increased. When rightly understood and applied this benefits the wage-earner, employer and public as well, and goes a long way toward the solution of the labor problem which is inseparable from the cost of living.

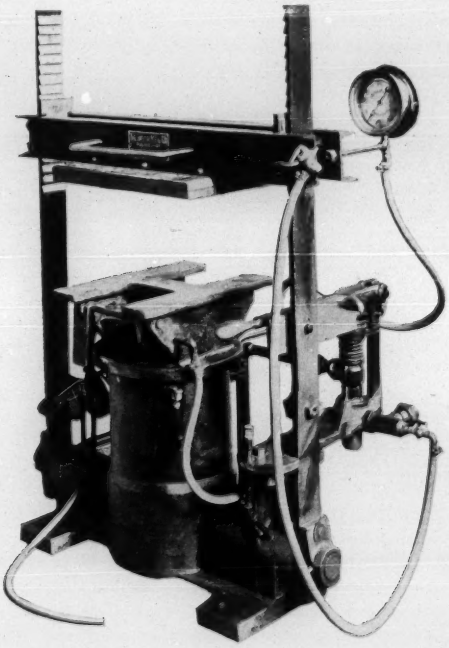
Improvements in machinery, combined with power for its operation, have worked wonders in the output of labor, but only a fraction of what can be realized from the same amount of human effort when more intelligently directed and controlled. The all-round mechanics of former years have well-nigh disappeared and good workmen, if obtained at all, must be recruited from such raw material as can be found unemployed. There is always an abundance of the inefficient kind, and the problem now confronting the manufacturer is how to make it efficient and valuable. The answer to this is to be found in the introduction of an educational system of management not unlike the laboratory system adopted in some of our schools and colleges. Men must not be left to their own devices to pick up such knowledge as may make them inferior or merely good enough workmen. They must be systematically taught to perform the work assigned to them by shop bosses or foremen who are interested in the result, and whose chief function it is to teach. In this way every shop in the country may become in effect a trade school of the most valuable kind, in which the pupils are not only taught how to do certain things but how to do them quickly and well and earn a substantial reward commensurate with the skill attained. No labor-saving machine can produce results without human aid in one way or another, and many a machine, good for its purpose, has been abandoned to the scrap heap, not from any inherent defect or inability to effect a saving, but simply as the result of awkward or inefficient handling. We must have efficient workmen as well as efficient machines to obtain the best results, and foundries need both as much as, or possibly more than any other kind of operating plant to-day.

Although modern industry depends upon the foundry for a large part of its products and the ingenuity of inventors has been busily engaged for generations in the evolution of labor-saving machinery, very little of this effort has been devoted to the improvement of the foundry itself, and it is only within comparatively recent years that machine molding has developed much importance as an art. In the year 1800 an English patent was granted for molding screws, the patterns for which were backed out of the sand by lead screws of the same pitch. This was simply a pattern drawing machine of rather ingenious construction, but the English records do not touch again upon machine molding until 1839, when a very similar patent appears. From this time forward more interest seems to have been aroused and these patents were soon followed by others for packing sand by mechanical means, including hydraulic cylinders, stampers and rollers of the road-roller type. Machines for molding gears and pipes also appear in the first half of the nineteenth century, and in 1843 we find an American patent on the molding of cannon balls. Later, in 1869, the first jarring machine patent was taken out, and it is not proposed to give a history of the art of machine molding from patent office records but simply to point out that the art began in a small way on bench work and continued chiefly in its application to small molds that one or two men could handle until the end of the last century. Larger work was not generally regarded as applicable to machine molding until the jarring machine began to emerge from a long period of obscurity and demonstrate its peculiar fitness for ramming large bodies of sand. Its development for large work belongs mainly to the present century and through its means the art of machine molding has been extended to embrace nearly everything molded in sand. But there are, of course, exceptions and peculiar difficulties which will always depend upon the molder's skill for their proper execution, with or without the aid of machine, and like any other equipment the installation of molding machines must depend upon the saving to be effected by their use and the outlay needed to effect that saving. This leads at once to the consideration of foundry costs, the analysis of which should point the way to their reduction. These costs are made up of many important elements beyond the scope of the subject, and the effect of one item only need be considered, that of machine molding, leaving all other

items to be treated in the same way by those who are interested in attaining the highest efficiency in every detail of operation.

Machine molding began, as has been said, on small work and probably one of the best known appliances is the little hand squeezer. This is a very simple and effective machine de-

FIG. 1.

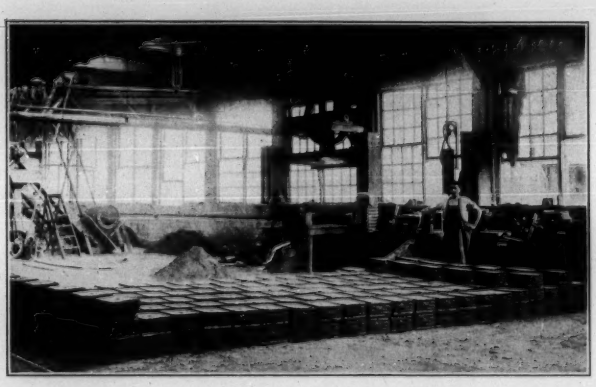


signed to save part of the time consumed in ramming. Figure 1 is a little power squeezer adapted to the same class of work as the hand squeezer which saved the work of ramming but put upon the operator the work of squeezing. There the man still did the work but with greater despatch, and therefore more efficiently. Here the machine does the squeezing and

the operator is less fatigued and can work faster. In support of this statement the floor shown in Fig. 2 may be offered as evidence.

Here 270 molds have been put down by one man in six hours and it is stated that this daily performance has recently been increased to 325 in the foundry of the American Hardware Corporation, where nearly 100 machines of the same type can be seen at work. Of course these performances by expert operators are not to be expected along the whole line, where the average may be in the neighborhood of 200 molds a day, but they show what

FIG. 2.



is possible, if not always probable, and it remains to be seen how a proper day's work on any given pattern can be fairly estimated. We are frequently asked to say what our machines will do and what production we will guarantee, regardless of the fact that we never know anything about the man operating the machine and seldom very much about the patterns to be used, the cores to be set or the precautions found necessary to insure success in molding the same patterns by hand. We know in a general way the type of machine required, but until we have actually made molds and poured castings, we are at a disadvantage and cannot safely guess at results which should be determined from a careful analysis of the experience gained in molding by hand. The

foundryman contemplating the introduction of machines has had the necessary experience, but he seldom, if ever, has it in a shape available for analysis, and the importance of making observations in detail and recording the time required for each and every step taken in the production of a mold will be shown. This has been brought out very forcibly by Mr. Knoepple in the April number of the *Engineering Magazine*. The suggestions there made are in line with the practice of the Tabor Manufacturing Company for the last five or six years, but the matter is one that has only begun to receive the attention it deserves as an important feature of scientific management. Consider, for example, a set of patterns mounted in a vibrator frame 13 inches by 17 inches for use on a squeezer. They can be molded either by hand or by power, but if we mold them by hand and note down the time taken by every step in the process we shall see where to look for a saving and what to expect when molded by power.

Fig. 3 shows the result of observations taken on molding by hand by an experienced man with a stop watch. The time is taken in minutes and hundredths for convenience in summing up. Items 4 to 11 inclusive have to be done in the same way and will consume the same time, .45 minute, whether the mold is made by hand or by power, as will appear in Fig. 4.

Item 12 must be done more thoroughly and takes more time when the mold is completed by hand.

Item 13 is not required for machine molding.

Item 14, butt ramming .30, is equivalent to squeezing by power, but it takes five times as long.

Item 15, striking off, is performed after ramming and takes .03 longer than striking off the unrammed sand on the machine.

Item 16 is not required in machine molding.

Item 17, rolling over, is the same in both cases.

Items 18 and 19 take .14 min. and only .08 min. when compressed air is used on power machine.

Items 20 and 21 are the same for hand or power molding.

Item 22 shows .56 min. by hand against .18 by power.

Item 23 is not done by power as a separate operation.

Item 24 is the same in both cases.

Item 25 to rap pattern takes .48 min. against .12 min. to start vibrator and lift cope at one operation on machine.

Item 26 is the same in both cases.

FIG. 3.

DM11 **INSTRUCTION CARD FOR OPERATION** SYMBOL

Sheets, Sheet No.		Drawing No.	H'nd Mol'g	Order No.	
Material	Class No.	Pieces in lot	Time for lot	Bonus	

Description of Operation. Molding Drag and Cope. (Part of Plow.)
Shown in Bulletin M. R. January 1st, 1911. (Page 8.)
Flask 13″ × 17″ 4″ Drag, 4½″ Cope Hand Molding at Bench.

Item	DETAILED INSTRUCTIONS	Feed	Speed	Element time per piece	Time for entire lot	Continuous or running time
1	Preparation					
2						
3						
4	Pick up hard sand match and put on bench			0.04		
5	Pick up pattern and put on hard sand match			0.04		
6	Pick up drag and put in place			0.07		
7	Shake parting on pattern			0.08		
8	Pick up riddle and put on flask			0.02		
9	Fill riddle with sand. One shovelful			0.04		
10	Riddle sand on pattern			0.08		
11	Fill drag with sand. Three shovelfuls			0.08		
12	Pein around edge of drag and butt ram some (with shovel butt)			0.10		
13	Put two more shovelfuls in drag			0.06		
14	Butt ram			0.30		
15	Strike mold off with bar 3/8 × 1 × 36 long			0.10		
16	Pick up bottom board and place in position			0.08		
17	Roll mold over			0.08		
18	Remove hard sand match			0.07		
19	Blow sand off of mold (with bellows)			0.07		
20	Repeat operations 6 to 10 incl. for cope			0.29		
21	Fill cope with sand. Four shovelfuls			0.10		
22	Repeat operations 12 to 15 incl. for cope			0.56		
23	Mark sprue hole (with cope board)			0.05		
24	Cut sprue hole			0.12		
25	Rap pattern. Spike going through sprue hole into pattern			0.48		
26	Round sprue			0.10		
27	Remove cope mold			0.09		
28	Blow pattern off with bellows			0.09		
29	Draw pattern from mold by hand			0.45		
30	Patch up mold (with slick)			0.30		
31	Close mold			0.12		
32	Remove snap flask from mold			0.07		
33	Remove mold to floor			0.07		
34						
35	Number 4 riddle.			4.20		
36						
37	Weight of shovel, 5 lbs.					
38	Weight of sand, 16 lbs.					
	Total weight, 21 lbs.					

When machine cannot be run as ordered machine boss must at once report to man who signed this card.

4	19	11	Signed DVM
Month	Day	Year	Checked

FIG. 4.

DM 11 **INSTRUCTION CARD FOR OPERATION** SYMBOL

1 Sheets. Sheet No. 1		Drawing No.	Machine No. M 10 32 R	Order No.	
Material	Class No.	Pieces in lot	Time for lot	Bonus	

Description of Operation. Molding Drag and Cope. (Part of Plow.)
Shown in Bulletin M. R. January 1st, 1911. (Page 8.)
Flask 13″ × 17″ 4″ Drag, 4½″ Cope. Power Squeezer.

Item	DETAILED INSTRUCTIONS	Feed	Speed	Element time per piece	Time for entire lot	Continuous or running time
1	Preparation					
2						
3						
4						
5	Pick up hard sand match and put on table of machine			0.04		
6	Pick up pattern and put on hard sand match			0.04		
7	Pick up drag and put in place			0.07		
8	Shake parting on pattern			0.08		
9	Pick up riddle and put on flask			0.02		
10	Fill riddle with sand			0.04		
11	Riddle sand on pattern			0.08		
12	Fill up drag. 3 shovelfuls			0.08		
13	Pein around edge of drag. (Butt of shovel.)			0.05		
14	Strike off with board and put in place			0.07		
15	Bring yoke over and squeeze. 60 lbs. pressure			0.06		
16	Roll mold over. (On table.)			0.08		
17	Start vibrator and remove hard sand match			0.03		
18	Blow off with compressed air			0.05		
19	Repeat operations from 7 to 11 inclusive for cope			0.29		
20	Fill up cope. 4 shovelfuls			0.10		
21	Repeat operations 13, 14 and 15 for cope			0.18		
22	Remove cope board			0.03		
23	Blow mold off with compressed air			0.05		
24	Cut sprue hole			0.08		
25	Start vibrator and lift cope			0.12		
26	Blow mold off with compressed air			0.05		
27	Start vibrator and draw pattern			0.10		
28	Close mold			0.12		
29	Remove flask			0.07		
30	Stop off carrier			0.06		
31	Place mold on floor			0.06		
32						
33				2.10		
34	Number 4 riddle					
35						
36	Weight of shovel 5 lbs.					
37	Weight of sand 16 lbs.					
38	Total weight, 21 lbs.					

When machine cannot be run as ordered machine boss must at once report to man who signed this card.

4 Month	20 Day	11 Year	Signed DVM
			Checked

Item 27, remove cope, takes .09 min.

Item 28, blowing off pattern with bellows, takes .04 longer than with compressed air.

Item 29, drawing pattern, takes .35 min. longer.

Item 30, patching up .30 min., is not called for on machine.

Items 31, 32 and 33 are the same in both cases; in molding by power an additional operation, stopping off carriers .06 min., is required.

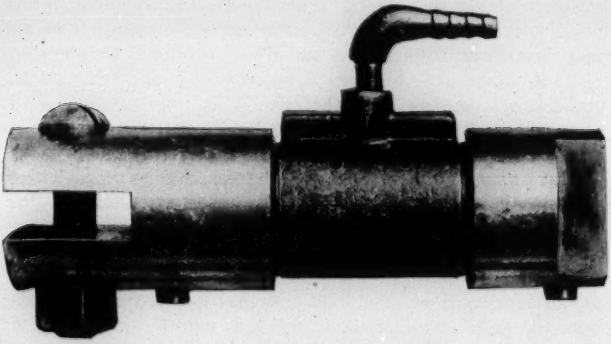
Fig. 4 shows the operations in detail for molding the same patterns on the machine. There are thirty operations by hand footing up 4.20 min. and 27 operations on the machine footing up 2.10 min., making the machine time just one-half of the time required when molding by hand without the use of compressed air.

It is also apparent from a study of these time-tables that the use of compressed air alone instead of bellows will effect a saving and that the vibrator in connection with hand molding will also effect a greater saving. Making the necessary substitution in Fig. 3 for the use of blower and vibrator it will be found that this additional equipment alone would reduce the molding time from 4.20 to 3.06 min. It, therefore, appears that the blower and vibrator can be used to save 1.14 min. per mold and the squeezer .96 min. more. This looks as though the blower and vibrator alone saved so much that it might not be worth while to put in the machine, but if we look again at the increased production, taking hand work as the basis for comparison, we see that the output from the use of the former is $\frac{4.20}{3.06}$ or 1.38, while from the use of the latter it is $\frac{4.20}{2.10} = 2$, that is an increase of only 38 per cent. on hand work against 100 per cent. on machine work.

But it may be argued that another element of time remains to be considered, and it must be admitted that no account has yet been taken of the time required to distribute a large number of molds on the floor. I do not know how far a mold can be carried and placed on the floor in .06 min., the time noted, but this time should be taken to about the middle of the space to be covered, and perhaps some additional time should be allowed for this item, but on the other hand it may be said that no allowance has been made for the inexperience of the operator, who was in

this case a pattern-fitter and not a molder or demonstrator. The time given will vary with different men, and it was taken in these cases simply for the purpose of illustrating the method by which important conclusions can be reached. No better data can be obtained for fixing prices, and when time is taken by an observer of experience who understands his business the stop watch never runs unless useful work is being done in the right way. A reasonable allowance should always be made for contingencies and a bonus put upon the performance of the work specified in the allotted time.

FIG. 5.



When patterns are cast in an aluminum match plate both cope and drag can be squeezed at the same time, the number of operations on the machine is reduced from 27 to 25 and the total time from 2.10 to 1.76 min.

The snap flasks used are of the usual type, and in these experiments about the same size, in this case 12 inches by 17 inches, 4-inch cope, 4½-inch drag. The machine will squeeze molds as large as 14 inches by 20 inches, but the best production can generally be realized on smaller sizes.

Instead of the aluminum match plate patterns may be mounted on a steel plate, and when split or flat back this is a very convenient method.

They may also be mounted on a paraffined board held in a vibrator frame, and when so arranged the molding time is substantially the same as for the aluminum match plate mounting.

Fig. 5 shows the Tabor vibrator, to which a large part of the saving effected by compressed air, with or without a power squeezer, is due. Power squeezers are made in various sizes, but the smallest size covers by far the largest field. It has been imagined that by increasing the size of flask and putting in more patterns greater production can be obtained, but this is seldom the case, and as previously mentioned the greatest output comes from medium-sized flasks easily handled by one man. Fig. 6 illustrates a small power squeezing split pattern machine with power draft. Machines of this type can be used with or without stripping plates and are applicable to a great variety of work made in solid or snap flasks. There is less handling time on this machine than on the power squeezer, and since each half of the mold is made separately the strain on the operator is not so great.

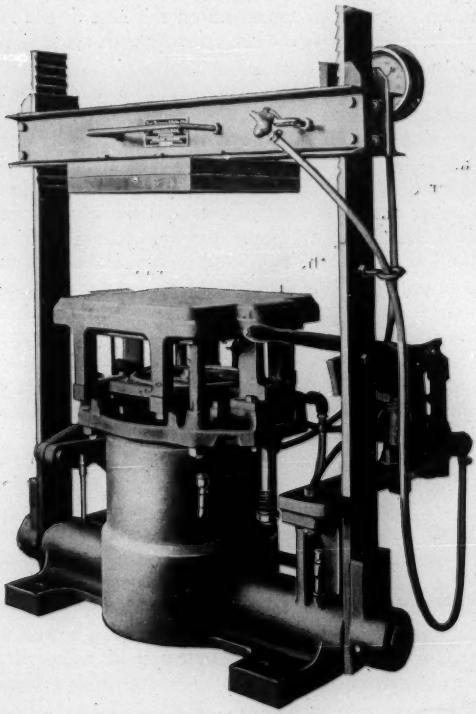
It is also possible to cope off, by means of supporting stools, pockets of hanging sand that would be impracticable on a squeezer. It is a very fast machine, but no illustration is as yet available to show where it gains on the squeezer by reducing the number of operations required and the total molding time. There are some jobs, however, which can be made as quickly on one machine as on the other, and although this is a much higher class of machine than the squeezer it does not follow that it is better for every purpose.

On such machines the cope and drag are frequently made from the same set of patterns, and it is therefore a matter of first importance to have them so located on the pattern plate as to match perfectly when the mold is closed.

Split pattern machines have been on the market for many years and their value is recognized and appreciated, but unfortunately they have to be built for a flask of fixed dimensions or at least fixed in length or width to fit the flask pins on the machine. They are expensive to build, rather inflexible in their application, and within the last few years they have been superseded very largely by roll-over machines with straight pattern draft to ram by hand or by power. An ingenious hand-ramming roll-over machine, with mechanism for rapping the pattern carrier and dropping the flask from the pattern, was brought out by Teetor in 1889, in which plated patterns are carried in a roll-over frame to which the flask is clamped and rammed in the usual way by hand. When rolled over a support beneath is brought up

by a hand lever, the flask is unclamped and the pattern rapped by turning a hand wheel on the trunnion shaft. At the same time the pattern is drawn by lowering the flask. A few of these

FIG. 6.



machines can still be found in use, but the rapping mechanism is not durable, the machine is rather limited in its scope and other types have displaced it for some time.

The French machine of Bonvillan & Ronceray is a modification of this type, in which the outer trunnion is omitted and

power is added for squeezing the mold and drawing the pattern. This will be remembered as having been exhibited at the Foundry Convention held in Philadelphia in 1907. It has a number of attractive features and is said to be very successful in France, where hydraulic power is more popular than it is here, but the machine has not been so successful on this side of the Atlantic, and it is doubtful that water can compete with air as a working fluid for foundry use.

The advantage of rolling over to draw a pattern is well known and in some cases it is an absolute necessity. This has led to the development of a large number of roll-over machines, nearly all of which drop the mold away from the pattern after the manner of Teetor. The one exception is shown in Fig. 7, and this lifts the pattern from the mold in what is generally admitted to be the logical way. Logical because the pattern is generally lighter than the mold and consequently preferably the part to be manipulated. The machine illustrated is shown as fitted with a grate bar pattern having 140 deep pockets, into which the sand is thrown by hand or settled by jarring the swing frame against its stops before ramming in the usual way by hand. Throwing the sand by hand is preferred, because the jarring process is not uniform and naturally varies with the distance of different parts of the pattern from the turning centre.

The flask used in this case is 14 inches by 37 inches by 5 inches deep and the time required for a complete cycle of operations was 5.81 min. The cope for this grate bar is almost flat and requires no machine. It could be made by a helper who would have time enough to spare to assist in rolling over, and probably eight to ten molds an hour could be made by experienced men.

In this machine, which takes a flask 24 inches wide and has 7-inch pattern draft, the swing frame and sliding head are counterbalanced by helical springs. These can be adjusted to the weights to be carried and the pattern is drawn by a hand lever at one side.

Since the weight that can be conveniently rolled over by hand is limited to three or four hundred pounds heavier molds naturally require power, and in Fig. 8 we have a machine which rolls over and draws the pattern by means of a cylinder and plunger, using compressed air on hydraulic oil or water to effect the movements.

The illustration shows the pattern drawn and rolling back

into position for another flask. In these machines a vibrator is attached to the swing frame and this materially assists in making a perfect draw, the main object of these roll-over machines. They are designed to save pattern drawing and finishing time,

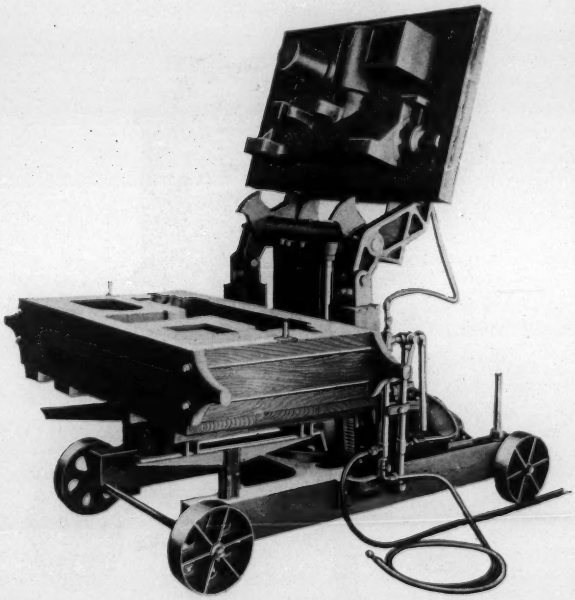
FIG. 7.

and where patterns are of such a character that the margin for this saving is small the time study will show it and possibly suggest a jarring machine instead. But molding machines do much more than save time in molding and are often worth all they cost in the saving of patterns, the saving in metal and the

saving in machine work by reason of the greater uniformity and closer finish of the castings produced.

An important feature of these machines is the levelling cradle, of which a number of types have been developed to set the flask with reference to the pattern board regardless of irregularities in the bottom board upon which it rests.

FIG. 8.



Such machines may be fitted with long patterns overhanging the swing frame for a considerable distance at each end. This possibility indicates the scope of the machine and the advantage of rolling over about an axis parallel to the length of the flask instead of about a normal axis as is done on machines of the French type.

Time study on large work may show that a material saving is effected in finishing, in ramming or in both, and where ramming time is the principal item a jarring machine is the equipment most needed to reduce costs. There are quite a number of jarring machines on the market, all of them covered by the original claim of Hainsworth in his patent of 1869, which is so refreshing for its simplicity and breadth that it is worth quoting:

"The packing of sand, for a mold, in a flask, by raising the same, together with the pattern, and letting them all drop upon a hard bed, substantially as shown and described."

There were no permutations and combinations of elements making an extended series of claims calculated to exhaust the patience of the reader. All he wanted was the whole field and he secured it in a single claim, but it is not certain that the packing of sand in this way was altogether original with Hainsworth, and there is ample ground to suspect that groceries of all kinds have been packed in paper bags by the same jolting process before the memory of man runs otherwise, and some of these (dried currants, for instance) there is reason to believe have always contained a liberal admixture of sand. The packing of sand by jarring is therefore in all probability as old as the hills, but since the broad claim of Hainsworth no longer troubles us we must look among later improvements within the field that he covered for the development of the art. This patent seems to have attracted very little attention when it appeared and no further inventions along this line are on record until 1878, when Jarvis Adams gave some impetus to the art and later followed it by a number of patents. The Adams machines were, however, rather crude and very little progress in the art was really made until compressed air came into general use as a medium for the transmission of power.

At the present time nearly all jarring machine builders contemplate the use of compressed air, whereas originally, and until about the beginning of the present century, they were operated mainly by hand or by cams on a power shaft. The development of the jarring machine is an interesting study, but no attempt will be made to follow it through all its ramifications; a few examples only representing the last ten years will be considered. In the machine first built the jarring table was struck underneath by a heavy plunger actuated by compressed air. The blow raised the

table a short distance from its support, upon which it fell back, striking a second blow. Some of these machines are still in use, but it cannot be said that they are very efficient or successful, and they were superseded five or six years ago by the Tabor jarring machine now in common use.

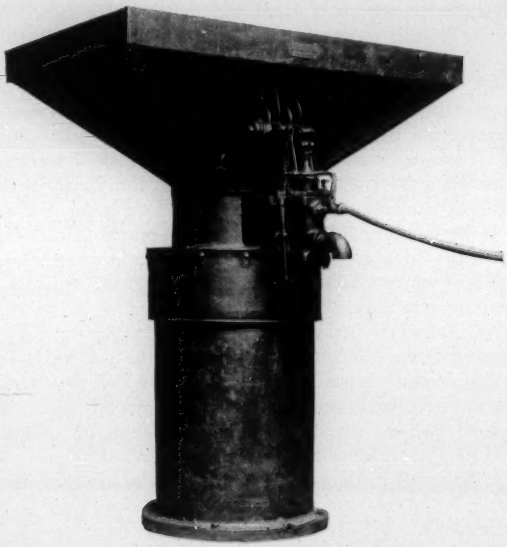
This is a plain machine with the jarring cylinder formed in the table mounted upon an upstanding plunger. By this construction the table is given enormous strength and stiffness and the central blow of impact is distributed equally in all directions. The plunger is part of a heavy piece of cast iron forming the anvil, which in turn rests upon a large mass of concrete. Originally the main valve was operated directly by tappets attached to the table adjustable for any desired length of stroke, and later it was modified to operate through the medium of a pilot valve. To avoid unnecessary intensity in the blow struck by the table upon its anvil a few layers of leather or other non-resilient material are introduced as a cushion. These reduce the wear and tear and noise, without having any material effect upon the action of the machine on sand. The plunger base rests upon concrete to form an anvil.

As to the mass of concrete, it may be said from the operating stand-point the more the better, but this must be limited, of course, with regard to the cost and the natural bed beneath. In a general way, about two cubic feet of concrete for every square inch of area in the jarring cylinder is recommended, but if there is a rock bottom beneath the use of very little concrete is advisable, or just enough to level up under the cast-iron plunger base. Some builders recommend more concrete than this, some less, and in addition to the concrete a heavy wooden cribwork is frequently put in beneath to prevent the transmission of the shock of impact into the ground. This is in accordance with the usual practice under steam-hammer anvils, and it may have some beneficial effect but it does not eliminate the whole trouble and the wooden crib is scarcely worth its additional cost. It is not generally safe to set up finished molds with hanging sand in the neighborhood of a jarring machine of this type and in some foundries the jarring machine has been put out of service for days or weeks pending the completion of large floor work. In fact, the damaging effect of large jarring machines is too well known to need confirmation, and to reduce this to a minimum the

drop of the table has been decreased while the foundation has been increased.

But there is a limit to the relief afforded by reducing the drop, because upon this the ramming effect primarily depends. The shorter the stroke the less the ultimate density attained and the less the efficiency of the machine. This can be demonstrated in a practical way by ramming up a deep mold on short strokes

FIG. 9.



until the sand ceases to pack any further. Increasing the length of stroke very considerably alters the effect of the next blow. The sand will pack further immediately and the conclusion in favor of the long stroke as more efficient in packing sand is inevitable.

With the object of eliminating ground shock and yet retaining the use of any stroke desired the Shockless jarring machine, Fig. 9, has been designed. It requires no foundation other than

a base to sustain the static load upon it, and it is more efficient in operation than a plain machine mounted on a wooden crib whose anvil weighs twice as much. The principle upon which it operates will be understood from the sectional elevation shown in Fig. 10. The plunger base forming the anvil is mounted for convenience in an anvil cylinder and rests upon a number of long compression springs. When air is admitted to the jarring cylinder the entire weight of the anvil, table, and load is carried upon these springs and they are therefore compressed and in readiness to expand when the air is exhausted and the table falls. At the beginning of this movement the loaded table is impelled downward by the same force that moves the anvil upward, and although some of the force of the springs is exhausted as the anvil rises the loaded table and the anvil acquire substantially equal momenta which neutralize each other when impact takes place. To compensate in a measure for the loss of spring pressure as the anvil rises, the exhaust from the jarring cylinder may be carried into the anvil cylinder before being discharged. This is accomplished by a combination valve, consisting of a large main valve of the steam-hammer type in connection with a small pop valve such as is used on small power squeezers and split-pattern machines. These valves are attached to the anvil or plunger base and the pop valve is opened and closed by tappets on the jarring table. When the table drops the pop valve opens, admitting pressure beneath the main valve, which rises and puts the jarring cylinder in communication with the air supply, at the same time opening the anvil cylinder to exhaust. When the limit of stroke is reached the pilot valve opens to exhaust and the main valve drops to the position shown. The air from the jarring cylinder rushes into the anvil cylinder, expanding to much lower pressure, which is nevertheless very effective in the large anvil cylinder and causes the loaded table and anvil to collide with greater force and effect upon the sand. The supply of air to these valves is controlled by an air cock at the operating stand and the table runs automatically as long as the air is turned on. At the same time the stroke of the table is controlled by another lever adjustable, if desired, while the machine is running. The purpose of the pilot valve is to provide a controlling means, easily manipulated, that will give the delayed action required by the main valve. This always presents full openings during the

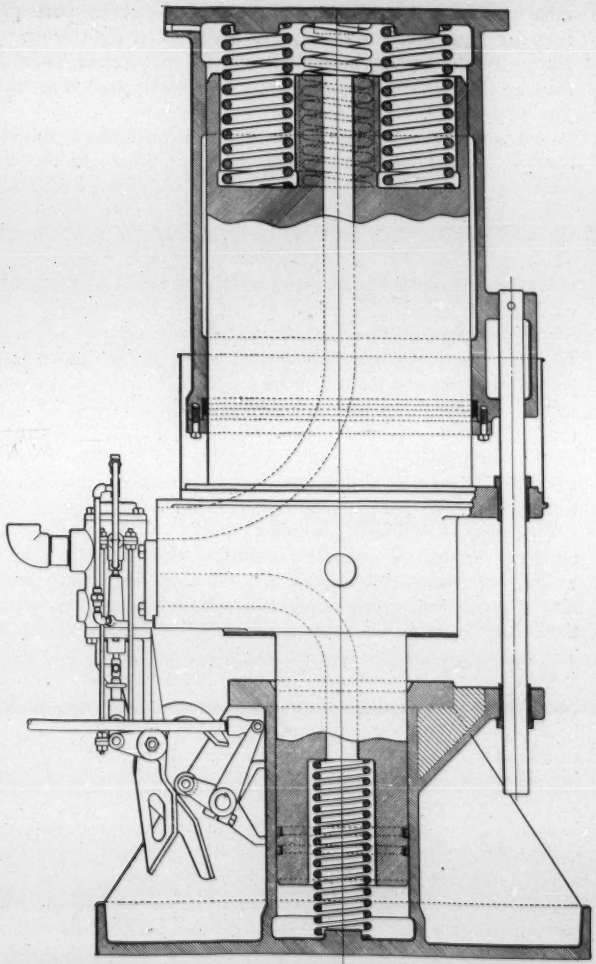


FIG. 10.

table movement up or down, and the ample lap on the ports gives time for expansion in the jarring cylinder under light or medium loads after the air supply has been cut off. Of course, under full load, or thereabout, there can be no appreciable expansion in the jarring cylinder.

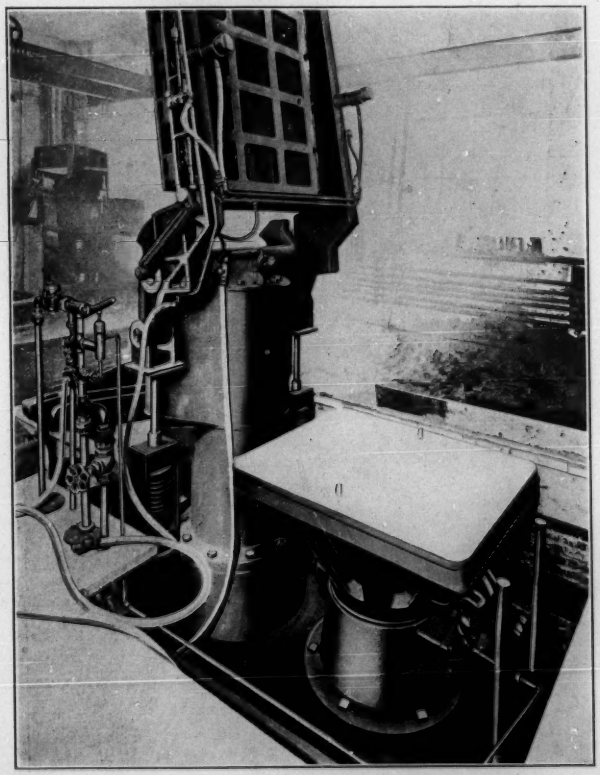
Fig. 9 is taken from a photograph of a 13-inch shockless machine with 4-foot by 6-foot table. A machine of this type will ram any mold, large or small, in a minute or less time, and the saving to be effected by its use on large work is practically the whole of the ramming time by hand. It will not ram small work, such as that on which time study was first given, as quickly as a squeezer or split-pattern machine, and such a jarring machine for half molds weighing less than 1000 pounds is not often recommended, but for large deep work particularly it is by far the best machine for packing sand. It is not, however, every pattern that can be rammed in this way, and care must always be taken to avoid projections on the pattern which interfere with the proper flow of sand. This sometimes necessitates the use of a core not required for hand ramming, but the patterns when mounted for jarring require fewer repairs and the cost of adaptation to the jarring process is soon recovered.

In regard to efficiency, nothing, of course, can be better than an anvil bedded on rock and therefore of practically infinite weight, but even a rock bottom does not prevent the transmission of ground waves, and when a wooden crib is used to cushion the blow the anvil yields to the impact and softens the effect. The advantage of the uprising anvil will therefore be demonstrated and its action illustrated by reference to two cars on a horizontal track. Let these cars be of equal mass or weight and let them be separated a given distance. Now block the wheels of one car and draw the other to it by a uniform force. Assuming the impact to be inelastic the two cars will move on together at half the velocity acquired by the moving car at the time of impact. The shock of collision is the same on both cars, one gains what the other loses, one-half of the velocity of impact, and the square of that change in velocity represents the ramming effect. If the stationary car had been of infinite mass the moving car would have lost all of its velocity and suffered four times the ramming effect.

Or, we may say, to invert the comparison, when one car

strikes another of the same weight the ramming effect is one-quarter of what it would be if the car ran into a stone wall, or encountered a mass so much superior as to have substantially the

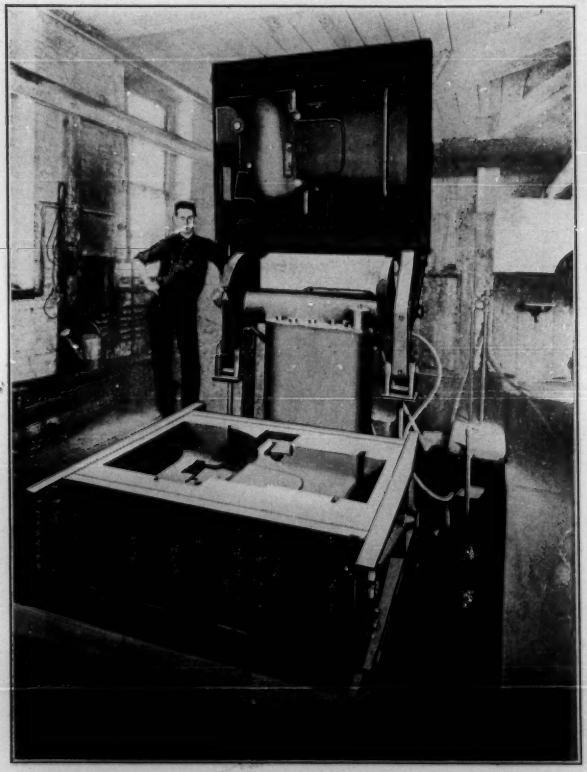
FIG. 11.



effect of infinite mass in checking its velocity. Now, if both cars are free to move and are drawn together by the same force as in the first instance, the same amount of kinetic energy will

be developed, but it will be divided between the two cars and totally absorbed by inelastic impact, each car sustaining one-half the shock instead of one-quarter. Therefore, when both cars

FIG. 12.



move together the shock of impact is twice as great as when one car waits to receive a blow from the other one. Furthermore, the highest efficiency, or the greatest shock, is realized

between any given pair of cars for any given amount of work done when both cars are actuated by the same force and acquire equal momenta in equal times. This is true for cars of unequal weight as well as for the cars of equal weight just considered, and it can be shown when one car is made heavier than the other to act as an anvil that when both cars are free to move the shock on the lighter car is greater than it would be against a car of double the weight standing to receive the blow. It is not claimed that the shockless jarring machine is always twice as efficient as a plain machine having the same weight of anvil mounted on a wooden crib, although it is sometimes more than twice as efficient. It is simply maintained that the shockless jarring machine is more efficient than a plain machine having an anvil twice as heavy mounted on a wooden crib. But the efficiency of a jarring machine does not depend altogether upon the weight of its anvil, solidity of construction contributes something and the length of stroke still more.

Instances could be cited where production has been increased five times by the installation of a jarring machine and still greater gains have been made from machines which combine the jarring and pattern drawing features just described.

Fig. 11 shows such a power roll-over machine in combination with a jarring machine.

Fig. 12 shows a grinder frame mold made on the same machine. This half mold was made by two men in ten minutes and a complete mold, including core setting, could probably be made in half an hour.

Originally two men made two molds a day by hand. With the aid of a jarring machine they made five a day, and it appears from the time taken on a combination machine that twenty a day might be expected.

Although the foregoing is not a complete summary of the art of machine molding and many types of machines have necessarily been omitted, the point to which particular attention may be called is the harvest awaiting the introduction of scientific management in the foundry and its bearing upon the proper selection and use of molding machines.

Arc Light Electrodes. (*The British Thomson-Houston Co., Ltd., Eng. Pat.* 13,518, June 3, 1910.)—The addition of a small proportion of chromium carbide is stated to increase the life of electrodes composed chiefly of titanium carbide. For example, an electrode may consist of an iron tube filled with a mixture of 4.5 per cent. chromium carbide and 95.5 per cent. of titanium carbide mixture, i. e., titanium carbide 99, sodium fluoride 1 per cent., or titanium carbide 96, sulphur 3, and sodium fluoride 1 per cent.

Effect of Ammonia on Nickel-plating Solutions. ANON. (*Brass World*, vii, 137.)—The presence of ammonia in nickel solution should always be avoided, for it makes the nickel deposit dark in color resembling iron, hard and brittle and lacking the tenacity and toughness of that formed in a neutral or slightly acid solution, and apt to peel. If a large amount of ammonia is present the deposit frequently flakes off in the solution, particularly if a high current density is employed.

Origin of the Thermal Waters in the Yellowstone National Park. ARNOLD HAGUE. (*Bull. Geol. Soc. Am.*, xxii, 103.)—The waters of these hot springs and geysers are characterized by frequent variations of temperature and chemical composition, lack of uniformity in mode of occurrence, and shifting of points of discharge. They are essentially meteoric waters that have penetrated downward sufficiently deep to become heated, and are forced back by ascending currents. These thermal waters hold mineral matter in solution, derived from the rocks through which they pass. They may be classified as (1) Waters carrying calcium carbonate in solution; (2) siliceous alkaline waters rich in dissolved silicic acid; (3) calcium siliceous waters, having properties of the two preceding classes; (4) siliceous acid waters usually holding free acid in solution.

Rules for the Prevention of Industrial Accidents. ANON. (*Amer. Mach.*, xxxiv, 1084.)—It is interesting to note the following rules issued by the Allgemeine Electricitats Gesellschaft, Berlin, for the guidance of employees using milling machines and circular saws. 1. All fast-running mills and saws must be surrounded with protecting caps. 2. Special care is to be taken that the stresses on saws and mills are exactly central, or in the plane of the cutter. 3. Damaged or sprung cutters are to be replaced immediately. 4. Small pieces to be cut must be fastened in holders and jigs; the cutting of small pieces held in the hands is forbidden under all conditions. 5. The chips thrown off are to be removed by sheet metal dippers or similar apparatus. 6. The wiping away of chips in front of the mill or saw is only to be undertaken with brooms or by brushes such as are supplied for this purpose.

THE USE OF PREPAYMENT ELECTRIC METERS.*

BY

F. G. VAUGHEN,

General Electric Company.

THERE is an old saying that "history repeats itself," and although this may not be literally true I think we will all agree that it is necessary to study the past in order to obtain a clear vision of the future. This is true whether we are considering the future of a nation, a man, or a meter; we must look into the past to determine what the future has in store.

The system of supplying various commodities automatically on the deposit of a coin is by no means a modern one, but may be traced to a period anterior to the Christian era. One author states that its invention may be attributed to Hero of Alexandria, a Greek mathematician and physicist, who is supposed to have lived in the first or second century B.C., and in whose "Pneumatics" is described a sacrificial vessel containing holy water which flowed only when money was introduced.

This vessel was placed near the entrance of some of the old Egyptian temples to enable the worshipper as he entered to sprinkle himself with holy water. Its operation was as follows:

When the coin was dropped through a slot it fell on one end of a horizontal beam which, on being depressed, opened a valve suspended from a chain at the other end and the lustral water commenced to flow through a pipe. When the beam had been depressed to a certain angle the coin fell off and the valve, which was counterweighted, again descended and closed the outlet so that the discharge ceased.

The mechanism of this ancient vessel was very similar to a modern automatic machine patented by Mr. Lewis G. Noble, of Boston, Mass., in 1889, which will for a penny dole out a small quantity of liquid perfumery.

It is rumored that even centuries before "Hero" the prepayment system was introduced by priests in the eastern temples to

* Presented at the meeting of the Electrical Section, held Thursday, February 2, 1911.

bring tears to the eyes of their gods. This was accomplished in the following ingenious manner: When the worshipper placed his offering on some portion of the image intended for its reception the weight of the offering acting on a lever operated a valve in one of the cellars of the temple. This cellar contained an apparatus filled with hot water, and the action of the valve caused steam to ascend through bamboo tubes to the eyes of the image, where it condensed and became transformed into tears. The

FIG. 1.

The first prepayment meter. (Date about 200 B.C.)

object of this, no doubt, was to impress the devotee and probably induce him to increase his contribution to the temple.

Truly, as King Solomon has said, "There is nothing new under the sun."

Coming down to modern times, we have only to look around us to see the variety of purposes to which the penny-in-the-slot idea has been applied and the immense popularity of this system for selling commodities. Instance the supply of sweetmeats, cigarettes, cigars, matches, postage stamps, post cards, writing paper, applications in restaurants and cafés where anything from a sandwich to a cocktail may be obtained by dropping a coin in

a slot and pushing a lever. Then there are the endless number of gambling machines which may be found in cigar stores, saloons, and hotels, the thousand and one applications in places of amusement, automatic machines for operating phonographs, motion pictures, etc.; photographic apparatus which takes your picture for a nickel and scales which will give your correct weight for a penny. We no longer have to worry even about our future, for "Madam Fortune Teller" will reveal this to us if we but

FIG. 2.

Automatic machine patented by Lewis G. Noble, of Boston, Mass. (Date, 1889.)

drop a coin in the slot. This same penny-in-the-slot idea is adopted in modern trolley cars where prepayment is made as you enter.

Indeed, we may exclaim with the poet:

"An age when all our daily wants,
Whether they be few or many,
Will be sufficiently supplied
By merely dropping in a penny."

A glance at the history of the gas business will show that these undertakings found a field for the prepayment gas meter and obtained great profits from its use.

As previously stated, the slot arrangement was originally used for supplying liquid from a sacred vessel. It was not applied to supplying light until 1887, when the first recorded application for this purpose was made by John Stewart Wallace, an Englishman. In the following year at a southern district association meeting held in England a Mr. W. E. Price, of Hampton Court, read a paper entitled, "Some Hindrances to the Sale of Gas." In this paper the deposit system was severely handled and the remedy shown, Mr. Price exhibiting his early prepayment meter effort. "We have no reason to suppose," says Mr. Price, "that the artisan has any hereditary love for the tallow dip or the paraffin lamp," and provided that gas is supplied on the "pay-as-you-go" plan he predicts an enormous increase in business.

These first meters were complicated pieces of mechanism, and although quite a few were sold, they were, for the most part, ordered in single lots to satisfy the curiosity of the purchasers in seeing to what lengths mechanical adaptations of the penny-in-the-slot principle could be carried. The prevailing opinion was that the meters would never be of any practical use.

Later a number of stop meters were introduced, *i.e.*, meters which could be set to shut off when a certain amount of gas had been used. This was a prepayment meter in a sense, inasmuch as the gas always had to be paid for before consumption. On the other hand it had the disadvantage that the customer could not buy at any time but only once a week or month. This system was not applicable to the working classes, as they could not be persuaded to buy a week's or a month's supply of gas in advance. Several of the more enterprising gas undertakings in England realized in a measure the enormous increase in their business which would result if the use of gas could be extended to the dwellings of the working classes. As these classes would not stand for the monthly bill or the deposit required when selling gas with an ordinary meter, it became evident that they must be reached through the agency of the prepayment meter.

About 1893 two very large gas undertakings, the Liverpool United Gas Company in the north, and the South Metropolitan Gas Company in the south of England bought a number of these meters and started a campaign to increase their business. Mr. George Livsey, in speaking to the shareholders of the South

Metropolitan Gas Company in 1895, shows how in eighty years the company had obtained only 80,000 ordinary customers; but that in two years the number of automatic consumers reached 20,000. In 1898 this figure had increased to 72,288.

The increase in the business of most other companies that introduced these meters was equally as great. One writer in 1895 says, "The remarkable figures of the Gas Light and Coke Company show that wherever the public can be supplied with all they want to properly use gas for both lighting and cooking upon inducive terms, even at a good round price, they will take it. They object to rentals and deposits, but willingly pay for all supplied in the price of gas."

Every one was astonished at the way the orders poured in. Gas fitters were at a premium, while manufacturers were unable to fill the orders. The rush commenced in 1894, and by 1896 the facilities of manufacture had been increased and the boom, which had reached its height at this time, steadied down to a fairly even but extremely copious demand.

The early meters made in 1892–3 gave quite a little trouble, arising in most cases from the almost clockwork delicacy of the working parts. As the business grew, however, improvements were made; the gas undertakings also became familiar with the devices and knew better how to overcome difficulties; and so the problems worked themselves out.

The enormous popularity of the penny-in-the-slot meter in England was due in part to the fact that the gas undertakings installed fixtures and gas cookers free of charge. At first a slight increase in the charge for gas was made, but this was abandoned later and still the companies made a good profit. The prime reason, however, for the success was the application of the "pay-as-you-go" principle to the sale of this commodity.

An aggressive campaign was issued and the people were shown the benefits to be derived from the use of gas. The tallow dip and the paraffin lamp were thrown aside by the laboring classes and the "pay-as-you-go" system of selling gas was welcomed.

It is estimated that there are to-day over 20,000 prepayment gas meters in use in the United States alone. It is not the practice of gas companies in this country to furnish stoves and fixtures free of charge. In England, where labor is not nearly

as well paid as in this country and where a large proportion of the population live from hand to mouth, so to speak, the use of the prepayment gas meter is more general. For instance, in London, where the poorer clases abound, there are 645,000 prepayment and only 384,000 ordinary gas meters.

I do not wish to infer that the gas companies prefer to handle the prepayment meter, for they undoubtedly do not; but they use this meter to cover a field which would otherwise be left undeveloped.

Since the prepayment scheme has been successfully applied to the marketing of the thousand and one commodities in daily use and has been found profitable in increasing the consumption of gas, why should it not be more extensively applied to the sale of electricity? In other words, is there any inherent reason why the prepayment electric meter should not play as important a part in the vending of electricity as does the prepayment gas meter in the vending of gas?

The application of the prepayment method to the sale of electricity is more recent and much less general than with gas. The prepayment gas meter was developed in England over a quarter of a century ago and has since become prominent in this country and abroad. I have understood that the adoption of the prepayment electric meter has been far more general in Europe than in this country and has met with success, particularly with supply companies of municipal ownership. While our experience has been more or less limited, I feel that it has been such that there is no diversity of opinion as to the numerous advantages of a reliable prepayment electric meter, and that it would be of material assistance in the sale of electricity.

That this meter has not as yet become very popular with central station managers there can be no denying. This, I think, has been due chiefly to two causes:

First, on account of the inherent complications of the device, which have made it difficult to build a satisfactory meter; and

Second, on account of the higher initial cost and increased expense of upkeep (*i.e.*, so far as the cost of testing and repairs is concerned) over that of the standard watthour meter.

These features have caused central station managers to hesitate about introducing these devices for fear that they would not be a profitable investment.

It is true that many of the prepayment devices which have

formerly been placed on the market have been unnecessarily complicated and costly. In justice to the manufacturers, however, it should be realized that the problem of constructing a successful prepayment electric meter has been exceptionally difficult. The gas meter is quite crude in comparison. In constructing the electric prepayment meter we have an electric arc to break in addition to the usual problems encountered in building automatic coin devices. This must be done in such a manner as to prevent pitting or otherwise injuring the switch contacts, since the switch is a vital part of the mechanism and must be absolutely dependable in its action.

Improvements have, however, constantly been made and it is now possible to obtain reliable prepayment meters for a moderate price.

There are two general classes of customers with whom every central station manager is very familiar: those of questionable credit and the delinquents. These classes are closely related and it is sometimes difficult to segregate them. Under the first would come the occupants of certain apartment houses—transient customers, if you please—who are here to-day and gone to-morrow; foreign districts in large cities where the Italians, Chinese, etc., abound. There might also be included in this class of questionable credit saloon-keepers, proprietors of gambling houses and other resorts needless to define. In fact, such customers are numerous in communities having a floating population such as large cities, manufacturing towns, and summer resorts. All or much of this business may be desirable if the question of credit can be taken care of. A prepayment meter for such installations insures payment in advance. It may also, in the case of the transient customer, save the expense of frequently removing and replacing the meter as well as an extra trip of the meter reader inspector.

The class of delinquent customers can readily be obtained from a careful study of the central station books. There is without doubt a small percentage of customers who are habitually behind in their payments. One or more collectors, depending on the size of the station, are often necessary to collect the bills of these customers.

The services of these collectors may be likened to the police department in a large city, which has to be maintained at a large expense to protect the whole body politic from the depredations

of the very few who compose the criminal element of the community. So the collectors are paid to keep after a small number of customers who are ever behind in their payments.

There are some who even avoid the collectors or refuse to pay them, in which case the company writes the customer and threatens to cut off the supply unless the bill is paid; and later, perhaps, is obliged to actually disconnect the circuit. Left in darkness, the customer generally pays his bill and the meter must again be connected. All of this means extra expense for the central station.

Now if these delinquents could be furnished with prepayment meters the company would not only save all of this expense incident to collecting but would free the customer himself from the annoyance of constantly being prodded. A discontented customer is always a poor advertisement; and if the friction between the central station and the delinquent customer, together with the cost of collecting, can both be eliminated by the use of the prepayment meter, it should pay a good profit on the investment.

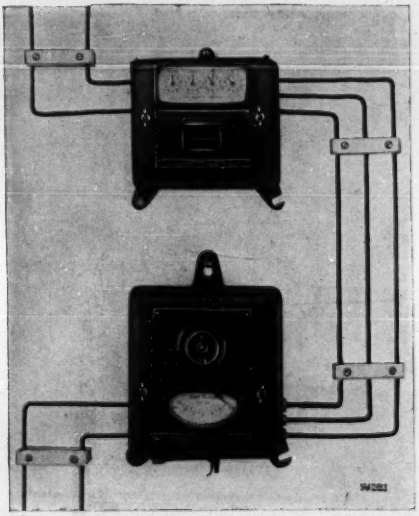
Besides the matter of collecting, it should also be remembered that the use of the prepayment meter will reduce the expenses of the accounting department by eliminating the cost of billing, and will also cut out the items of postage and stationery.

Another class of customers who cause the central station considerable trouble and expense may be termed, for want of a better name, "The Doubting Thomases." They are sure that their meter is reading too fast and that they are being robbed. To pacify such customers it is necessary to spend much time and money in making frequent explanations of the correctness of bills. Often the customer insists on the meter being recalibrated. He lacks confidence in the device and must be shown that it is accurate.

Now in the majority of such cases the meter is practically correct. The customer has failed to realize that the days are growing shorter; that perhaps he has been entertaining more than usual; or has recently purchased an electric flatiron, fan motor, or other auxiliary device which is consuming more power. Some companies instal a prepayment meter on the premises of such a customer, connecting this in series with the regular watthour meter. In this way the customer can check his meter and at the same time often finds out for himself where the extra power

is being used. If, for instance, he has to make an extra deposit he remembers that he forgot to turn out the cellar lights the day before, or some other cause for this increased consumption will likely occur to him, whereas if he didn't pay his bill but once a month he would not remember the little instances which make it abnormally large. In a very short time the prepayment meter

FIG. 3.



Standard Watthour meter and prepayment meter in series.

may be removed from such a residence and it generally leaves a contented customer where it found a chronic faultfinder.

Again, there are a large number of people who belong to the so-called "pay-as-you-go" class who think nothing of spending a considerable amount of money in small instalments, but who look on the monthly electric light bill as a burden and will not use electricity for this reason.

In these days when the central station is reaching out on all sides for new business and resorting to all kinds of schemes in

order to make electricity popular, why not try and reach this pay-as-you-go class through the agency of the prepayment meter?

All customers who are mentioned above, and perhaps others familiar to the supply companies, are revenue producers but not in the average profitable, due to expense involved for reasons outlined above; yet the supply companies cannot afford to lose or refuse to do business with them. The prepayment electric meter provides the simplest and most feasible solution of cases herein cited. How simple it would be for the commercial department of the supply company, with the electric prepayment meter at its

FIG. 4.

Prepayment meter.

disposal, to deal with prospective customers, either through solicitation or application, that have no credit standing but whose business looks desirable except for the one reason—poor or doubtful pay—to eliminate the usual routine and say, "We will put you on prepayment basis" and therefore close the business without delay and further expense to the supply company.

Of course, each central station must work out this problem to suit its own local conditions.

There is no doubt whatever that the prepayment meter is particularly well adapted for the field specified above and the wide-awake central station manager will find where he can increase his profits by its use.

To meet its field it is evident that the successful prepayment electric meter should be of simple and robust construction, made from good materials and with the best of workmanship, having as few delicate parts as possible. It is the tendency of the designer to-day to follow as nearly as possible mechanical principles, thereby aiming to avoid a complicated mechanism. The fact should not be lost sight of, however, that no automatic device—no matter how simple—can be left to itself year in and year out

FIG. 5.

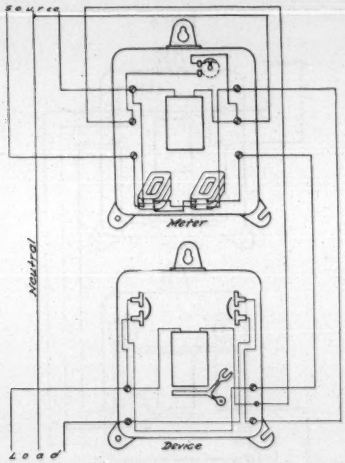


Diagram of connections.

without any attention whatever and be expected to do its work in an entirely satisfactory manner.

A successful prepayment meter should be reasonable in price, reliable, accurate, and unalterable by anyone not in possession of a key. The actuating force of the device should be foreign to the meter proper. It should be adapted for any commercial rate of charge and should be so constructed that this rate can be easily changed.

It should be designed to operate with a standard coin of wide circulation. Provision should be made so that several coins may

be inserted in succession, after which the coin slot would be automatically closed.

It should have a dial to record the total energy which has passed through the meter and a pointer to indicate at all times the number of coins which remain to the customer's credit.

It should have a reliable switch, preferably of the double pole type, for opening both sides of the line.

The General Electric Company has recently placed on the market a new prepayment attachment for use with the Thomson watthour meter which meets the above specifications.

FIG. 6.

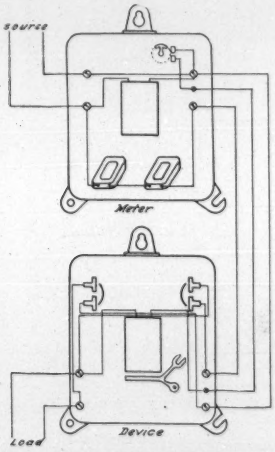


Diagram of connections.

The attachment may be furnished either in combination with the General Electric Type I High Torque Induction or Type C-6 Direct Current watthour meters or as a separate device. The principle of operation is the same in either case, but the connection between the meter is mechanical in the former and electrical in the latter.

The combined attachment, however, is the one most generally used and seems best adapted to meet the majority of service conditions. It has the distinct advantage of being complete in

itself, depending on no auxiliary device, occupies a minimum space and requires the least amount of material and labor for installation. The separate attachment is available for use on those installations where it seems advisable to place the device in a more secure or accessible position than the meter itself.

In the case of the Thomson watthour meter with separate prepayment attachments the meter proper is standard with the exception that it has an extra terminal for making connections with the solenoid circuit of the device and a special register with contact brushes for closing this circuit at the proper time and thus operating the prepayment mechanism.

The actuating force which operates the device is a large, flat coil spring enclosed in a barrel or drum to which its outside end is attached. The operating knob winds this main spring by turning the drum. The spring has many turns, and as the operation of the device never equals one whole turn the spring always exerts a practically constant force.

The coin chute and receptacle in the combined device are at the back of the meter, so that when the meter is inspected or repaired the coin box is not interfered with in any way.

The switch is of the double pole, double-break type with leaf contacts and toggle joint. The double pole arrangement permits the meter to be used on both two- and three-wire circuits; while the toggle joint insures a good contact which is undisturbed by any jar, and at the same time prevents any back pressure from being transmitted to the escapement train.

The meter can be furnished for any commercial rate of charge. The rate device consists of a small train of gears, furnished as a separate member, which may be easily removed and replaced by the company in case it desires to change its rate of charge.

The meter is operated by a 25-cent-piece and every precaution has been taken to prevent fraud. A coin larger than a quarter of a dollar cannot be introduced into the receiving slot, while smaller coins will not operate the device.

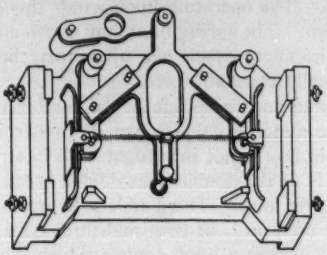
When it is desired to make a deposit the winding knob is turned so that the arrow points upwards. A quarter dollar is then inserted in the slot and the knob turned to the right.

The coin serves as a key to operate the mechanism in the device. If the circuit is open when the coin is inserted the same motion of the knob, which moves the registering mechanism, closes the circuit switch contained in the attachment.

The dial plate of the combined prepayment meter contains, in addition to the standard four-pointer dial, a scale over which a pointer passes indicating the number of coins remaining to the credit of the customer. When the meter has a separate prepayment attachment the dial showing the number of coins standing to the customer's credit is placed on the attachment.

When the first coin is deposited and the knob turned closing Twelve coins can be deposited consecutively, after which the scale. If a second coin is deposited before the current purchased with the first coin has been consumed, a second motion of the knob will bring the pointer opposite the second division on the scale.

FIG. 7.



Switch used with prepayment meter.

Twelve coins can be deposited consecutively, after which the slot is automatically closed and further prepayment cannot be made until the value of one or more coins has been consumed. Whenever energy to the value of one coin has been delivered through the meter the escapement is released, mechanically in the combined device and electrically in the separate device, turning the pointer back one division. This process continues until all the energy for which prepayment has been made has been delivered, at which time the circuit switch is opened and no more current can be obtained until more coins have been deposited.

SMALL PUBLIC SERVICE PROPERTIES AND THEIR FUTURE.*

BY

W. S. BARSTOW.

As we have followed the development of public service corporations we have come to realize their every-day influence in large communities where they have become indispensable wheels of industrial progress.

The small communities noting the valuable contribution such corporations offer, set about to at once secure some of these advantages.

The public service corporation of the large community, after passing through the dark days of early development, has practically and satisfactorily solved its problems. Fortunately for itself and the public this development has been in the hands of broad-minded men who, overlooking immediate but ofttimes temporary success, have striven to build up a permanent industry on a firm foundation.

In these days of public clamor against the large corporation or—in newspaper language—the trust, it is interesting to study the subject from the commercial and practical point of view, setting aside for the time being the various theories which exist as theories but not always as facts. In this the engineer, accustomed as he is to deal with facts as well as theories, is well fitted to set aside sensational sentiment and regard the subject in an every-day practical light as to the effect of the large public service corporation existing—if you please, as a monopoly—on the public in general. By "public in general" is meant not only that portion occupying the dense centres of population but also that portion which in scattered communities contributes equally in shaping general progress.

The small towns of some 5000 population question among themselves, without in any way differentiating as to local sur-

* Presented at the meeting of the Mechanical and Engineering Section held Thursday, April 6, 1911.

roundings, why, if gas, electric lighting and railway properties are such contributors to the upbuilding of a large city, they would not be equally stimulating to smaller communities. The small company is started on misconceived notions as to financial results, without proper investigation of local conditions or conclusive, well-developed plans for future growth. Review carefully the years of study of service, rate questions, engineering problems, etc., that the large corporation has passed through and contrast them with the haphazard manner which characterizes for the most part the birth of the small property. As a general rule the enterprise is hurriedly conceived without any reference to permanent success.

We will not dwell upon the small town electric railway, for its life is generally short and if not, its death is lingering. A recent application before a public service commission of an eastern State prayed that permission be granted to remove and sell two out of the three miles of track so that the company could secure funds to purchase a new car and enlarge the car barn to accommodate the car, setting forth that unless this petition was granted a receiver would operate the property. Numerous citizens appeared at the hearing to protest on the basis that the franchise covered the full three miles, as the town desired to populate this three miles and could not as well do so without the car line. The application was granted and the road is not in a receiver's hands—yet. The history of the particular enterprise is interesting. The venture was promoted by a leading citizen of the town who gathered together sufficient local funds to, as was expected, complete a three-mile railway system. It was submitted to an engineer who reported at once that the enterprise could not succeed owing to the small and scattered population. The citizens replied that their conditions were particularly fitted for its success and forthwith sought another engineer who gave a decision agreeing with that of the first engineer, at the same time adding that the estimate of cost was entirely too low. The road, however, was built by local talent and before purchase of proper rolling stock was completed all available funds were exhausted. The citizens who had contributed were few and wealthy but to save, as they thought, what they had already invested, made the application to reduce the length of the track system, and the balance of the population who never rode but prided themselves upon the town possessing a street car system, protested. The only final

salvation of such a small enterprise is the hope that some day in the near future the mile road may become a link of an inter-urban system.

The birth of the gas or electric property is somewhat similar. One or two public-spirited citizens, eminently successful in their own manufacturing or mercantile business but utterly oblivious or not even suspecting the difference between selling a commodity and rendering a service, spend a few hours debating the subject, call a general meeting and the public service seed is sown—a seed which, if it is fortunate enough to escape municipal soil, is planted in unprepared ground. The gas or electric light proposition appeals to the quiet citizen as a new thing—a new toy, which at least for a short time will furnish amusement, and at the same time, to his mind, be productive of profit. The leading citizens, forming themselves into a committee, devote their spare time in general investigation. They find the large companies of neighboring cities well financed, well engineered and well operated, giving good, reliable service and in return securing a good and proper income. The last appeals to the small citizen and without further investigation a report is made to the effect that allowing for the wasteful (?) methods of operation which they had observed in large cities the returns should easily amount to 20 per cent. on money invested,—and forthwith the local company is formed. General interest grows—the town paper, heretofore padding its news columns with associated press clippings, at once hails the venture with joy and assumes a public protecting attitude against the proposed gas or electric "trust." Every issue contains advice. A wealthy gentleman of leisure, having made his fortune in mercantile business and having a son employed in a hydro-electric station in the northwest, not financially interested in the local undertaking, deplores the shortsightedness of the promoters who insist upon the adoption of steam power when right beneath their very eyes runs the town brook which contains at least four ripples in the length of a mile and such a lot of water *in the spring*. Another party, having served his time as oiler in a large plant, deplores the adoption of the small unit of one hundred horsepower when looking ahead in keeping with the rapid (?) growth of the town a five thousand "kilewag" unit would be the proper thing. Again, a retired gentleman having a few shares of stock in a small steel company thinks the gas proposition as a pure gas proposition all wrong,

for if a coke plant was built the gas would be a costless by-product. After a few more such items of "*advice from one who knows*" the financial heads of the local company hold a meeting and resolve to hire the expert services of the ablest engineer and have him tell them all he knows "for a fee not to exceed one hundred dollars, which if possible should cover the plans of the plant." After vainly seeking outside talent in accordance with the terms of their resolution they appeal to the town electrician, who in the meantime has been busy "reading up," and impressed with his discourse on "frequency, resonance, induction, etc.," engage him at once at fifty dollars (thus saving (?) fifty dollars), and to them their troubles are over. (This is an actual history of a small service property and is typical of the majority.)

And now to follow a company, underfinanced and engineered. I was asked to value a small property which was about to pass into receiver's hands. The local engineer and superintendent met me at the railway station. He was blue; the enthusiasm of starting a new enterprise had vanished as had also the cash capital of the company. He explained sincerely that he had done *his* best. He had started the plant with 133 cycles, had quickly seen his mistake and added some 25 cycle apparatus, had later noted the rapid progress of large Edison plants and had forthwith added a direct current system—this in addition to a series arc direct current and enclosed arc alternating street system. He felt sure he had been progressive and up to date and could not understand the receiver proceedings. "The plant had only been in operation four years and no enterprise could expect to make money at the very start." After becoming better acquainted I found him earnest, willing and honest and an indefatigable worker, completely wrapped up in the undertaking, arriving at the plant at seven every morning and never leaving until nine or ten at night. He would have made an efficient and conscientious subordinate but without a master mind to direct his energies he was helpless and in fact a positive danger to the proper development of an enterprise.

Another property was about to pass into the hands of new owners and a balance sheet was asked for. It was a wonderful balance sheet. The bookkeeper frankly admitted he did not know what had become of the surplus and no accounts, as kept of the company, seemed to dispute his assertion. He stated he had spent many nights trying to secure a balance and had finally

done so by adding an item of miscellaneous expenditures. When asked what these covered he stated "you can search me but I am dead sure it will not balance without them." The engineer of this property had been operating the plant with a handbook. He had purchased a new piece of apparatus and after operating it a week telegraphed the maker "Send man at once, instruction book says there are thirteen oil holes, have lost one and cannot find it." And yet there are thousands of such men operating small stations who, implicitly following set rules of operation, are mere machines. When troubles come, as they inevitably do in electric light or gas plants, confusion reigns and poor service results.

As a general rule the independent small plant, which to all outside appearances is prosperous, conducts its operations with no thought of depreciation, an open construction account, and an ability to incur an unlimited floating debt. Under such encouraging (?) conditions dividends are easily earned and declared only to find at a future period that something is wrong somewhere and expert service or a receiver is necessary to continue the enterprise.

The problems of the small corporation are perhaps of secondary importance as affecting the general development of the art, but to the small investor and operator, they are intricate and difficult of solution owing to narrow financial margins. In many cases the fault lies in the conception of the venture.

Generally speaking, no community of five thousand or less, and few of ten thousand population, can independently support a public service enterprise.

The first problem of a small gas or electric company is the making of proper provision for economical financing, not only at the start but afterwards to keep up with the growth of the community it serves. Its original backers soon tire of its continual call for new capital, especially if they have been disappointed in their expectations as to returns. The company endeavors to bond its property but soon tires of the efforts necessary to enlist the attention of the individual investor—individual investor, because in order to enlist the services of the banker and his clients the bond issue must be of considerable size and the enterprise well known. Thus in almost every case the small company turns to its local banks, which, as long as the amount involved is small and the loan prop-

erly secured, may aid the undertaking. But this is not permanent financing, for there soon comes a time when the local investor is not desirous of increasing his holdings and the bank can no longer consider so much of such collateral which is not easily and quickly convertible into cash. The inevitable result is necessity for curtailing all construction improvements or extensions and soon strict economy (?) in operation results in poor service and lack of proper provision for depreciation.

The second problem of the small property is the securing of proper engineering and operating services. This is difficult because ofttimes it requires the very best of talent to overcome the many little daily difficulties the correct solution of which is vital to the success of the enterprise, and the finances do not permit of the expense of such talent.

How then is the small property to be cared for and its future safeguarded? Where a number of small communities are within the proper engineering radius of supply, or adjacent to a large property, financial and physical consolidation supplying all from a common source is without doubt the solution of the problem. The securities in this case are of sufficient size to interest the banker, who relieves the company from this financing burden. All engineering and operation is under a common efficient head and its cost being distributed does not impose a burden. The radius of such supply, with advance in the art, is constantly increasing until to-day we see many small communities in the northwest and elsewhere receiving the very best of service over transmission lines several hundred miles in extent and covering territory remote from railway or civilization where electric irrigation or electric mining is opening up a wilderness hitherto almost unknown.

In this locality the proposed Lehigh Valley electrification will cover the territory with transmission lines which form a common source of supply, will aim to efficiently serve the greater part of some 2,500,000 people living in this region. Under these conditions the small communities are bound to thrive as never before, for the citizen with improved means at his disposal and relieved from the petty trials of the local plant can devote all of his best energies to growth of his own business in the development of which he can render his greatest service to his community.

But where physical consolidation is not yet possible, owing to location or other restrictions, what is the future of the small

property? Where such is the case financial, engineering and operating consolidation will take the place of financial and physical consolidation. One large corporation (which may be termed if desired, a holding company) by the acquiring of the small properties can consolidate the various securities into one, thus indirectly placing the small properties collectively on the same financial basis as the single large operating company.

At a Convention of the National Electric Light Association held at Atlantic City some few years ago Mr. Frank A. Vanderlip of the City National Bank of New York, gave an address which pointed to the solution of the financial problem of the small property. The substance of his remarks was to the effect that while engineering had undoubtedly solved the operating problems of small properties by a supply from a common source —a difficulty now existed on the financial side. The banker is interested in and could finance propositions where the amount of the securities was large and the properties and their management known. The difficulty existed in the financing of small independent properties which were not financially consolidated, where the amount of the individual securities was small and the management unsettled and unknown. The solution, according to Mr. Vanderlip, was a consolidation of such securities. Thus, if in place of ten small properties of 10,000 population each, having bond issues of say $100,000 each, which small amount would not interest the bankers, there could be one bond issue of $1,000,000, covering a combined population of 100,000, a condition would result which would at once invite outside financial aid. The banker must be conservative and protect his clients and he sees in the small independent property the chance of a single accident imperilling the earnings of the property even to an extent which might affect bond interest.

A holding company owning and consolidating all the bonds of several small properties, at the same time providing for supervision of operation, can increase the factor of safety and can secure for the small property favorable banking consideration and cheaper financing. A small property in Pennsylvania in a town of some 10,000 population has been endeavoring for some time to dispose of an issue of $50,000 first mortgage bonds. The plant is in good condition, the management unusually efficient, the franchise fair to the company and the public and yet efforts have been made time and again with resultant failures to market

such bonds at 80 or at a loss of $10,000 to a company where every dollar counts. As a comparison with this we have a smaller company in a community of one-half the size which, under the wing of the holding company, secures 90 for its bonds, simply because these bonds being part of a large consolidated issue and being marketed with additional bonds covering requirements of sister companies, make in the aggregate an issue which is at once attractive and safe, depending as it does upon the average results of several companies.

By centralized supervision of operation the best talent is instantly available and at a cost proportionate to the size and importance of the property. Supplies hitherto purchased from retailers in small quantities can be secured at prices which show considerable reduction and the ever present question of depreciation can receive its proper consideration.

But the question naturally arises, if the solution of the future of the small properties is either in direct consolidation with a large operating company, or in what might be termed indirect consolidation with a large holding company, although in either case the small property may be best taken care of financially and otherwise, what will be the result? In other words what will safeguard the public interest? The theory that competition is in any way a solution is out of the question where franchises and occupation of the same public property are concerned, and where the service to be performed can best be done economically by a single company. The answer to the question brings in *supervision* and *regulation*, and in this connection I quote from a speech recently made at Syracuse, N. Y., by Mr. E. J. Page, who spoke of the relations between railroad men and the Public Service Commission.

"Your predecessors," he said, "and the predecessors of the stockholders of the corporations you operate did not understand the meaning of the term 'Public Service corporation.' They seemed often to think that the service was or should be rendered by the public for the benefit of the corporation to the end that it might pay dividends to its stockholders. The feeling of obligation to the public was too often lacking. That day has happily passed away and most people familiar with the spirit and practice of the managers of the public service corporations have come to realize that the assets of every public service corporation are divided into two classes. The tangible assets represented by

capital stock securities held by the people who have furnished the funds and skill necessary for the creation of those assets. On those securities they are entitled to income in the form of interest and dividends. Then there are the intangible assets represented by the franchise furnished by the general public and on this the general public is entitled to income in the way of good, prompt, safe and efficient service at as low a price as is consistent with good financial management of the corporation. The corporation first in any public service field should be protected to the exclusion of all other applications so long as it renders such service as the public is entitled to receive."

And another by Mr. Theo. N. Vail, of the American Telephone & Telegraph Co. President Vail in his report to the stockholders says:

"Public control or regulation of public service corporations by permanent commissions has come, and come to stay.

* * * * * *

"State control or regulation should be of such a character as to encourage the highest possible standards in plant, the utmost extension of facilities, rigid economy in operation, rates that will warrant the highest wages for the best service, and such certainty of return on investment as will induce investors not only to retain their securities but to supply at all times all the capital needed to meet the demands of the public. Such control and regulation can and should stop all abuses of capitalization, of extortion, of overcharges, or of unreasonable division of profits."

The cost of service depends to a very large extent indeed upon the volume of business. In order to reduce the cost to the lowest point all available business must be secured and this results in a monopoly. The Public Service Commission of the Second District of New York states, in the case of the Binghamton Light, Heat & Power Company, "A public service corporation is in its nature an essential monopoly. A monopoly by the very fact of being a monopoly gets all the business there is . . . With a monopoly, if the density of the business gives extravagant profits, it is the duty of the State to cut down the price so that the monopoly obtains only reasonable returns. The evil of monopolies is that uncontrolled they can charge prices which will give excessive and unreasonable profits."

This brings us to the Public Service Commission per se. The greatest argument against the Commission is the uncertainty of

its personnel, but is this not also true of the entire structure of government under which we live? There is no question or doubt in the minds of the financier, the engineer, or the thinking public that the Public Service Commission as a regulating commission has come to stay, and already it has shown its value in acting as a safeguard to the company as well as the public. Too many people do not understand the functions of the Commission. It does not, as many suppose, espouse the cause of the people against the corporation, but simply acts as a Court of Justice.

In the brief history of our Eastern commissions, notably those of Massachusetts and the Second District of New York, there are countless cases on record showing clearly the impartiality of their decisions and the resulting benefits to the company and to the public. One example will suffice. A corporation receiving a franchise from the public must secure permission to exercise such franchise from the Commission. If a franchise through politics or otherwise is granted from the same territory or community in which a company is already doing a similar business, and if the company is living up to the requirements of the law as required by the Commission, the corporation securing the second franchise will not be permitted to exercise it. In other words, the Commission creates a monopoly, *but subject to laws which it can enforce.*

Many financiers are fearful that the Commission will so adjust profits that the future preservation of the property will be in danger. This has been shown by the decisions of all commissions to be the reverse. The question of depreciation itself, often lightly dwelt upon by the operator, is counted by the Commission as an element of the cost. The return on the investment has not been limited to the legal rate of interest but to rates *commensurate with the risk of the business.* Recent decisions have been rendered to the point of including surplus in the item of cost, as only in this way fair returns on capital invested can be secured *at all times,* thus preserving the credit of the company in times of depression and so indirectly benefiting the public.

Give us an efficient commission that will devote its efforts to the regulation of the public and the corporation, an honest and reliable management ever desirous of keeping abreast of the times in meeting the ever increasing requirements of the public and we will at once have a stable industry meeting all the expectations of the investor, the operator and the public.

THE COEFFICIENT OF EXPANSION OF TAR.

BY

JOHN MORRIS WEISS,

Barrett Manufacturing Company.

Coal tar and other tars are commercially bought and sold by the gallon, and as temperature plays an important part in liquid volume measurements it is essential to know the effect of changes of temperature on volume. This knowledge is summed up in the coefficient of expansion. Now, coal tar from various sources varies considerably in composition and hence also in its expansion coefficient.

In this paper are presented tests of various kinds of tar, along with their coefficients of expansion as determined in the laboratory.

The method of procedure was simple. The specific gravity of the tar was determined at various temperatures compared to water at the same temperature. A specific gravity bottle of 50 c.c. capacity, whose weight and water content at various temperatures were known, was filled three-quarters full of tar and weighed. Then water was added, adjusted to the temperature desired and weighed.

a = weight of bottle.
b = weight of bottle + water at t°.
c = weight of bottle + tar.
d = weight of bottle + tar + water at t°.

$$\text{Specific gravity: } t°/t° = \frac{c-a}{(b-a)-(d-a)} = \frac{c-a}{(b+c)-(a+d)}.$$

From this figure the density, or a direct mass and volume relation, could be readily obtained by multiplying the specific gravity by the density of water at that temperature. This can be seen in the following formulæ:

Let D_t = density of tar at $t°$.
M = weight of given quantity of tar.
V = volume of that tar.
D_w = density of water at $t°$.
M_w = weight of an equal volume of water at $t°$.

The known equation is—

$$\text{Specific gravity: } t°/t° = \frac{M}{M_w}$$

Now

$$D_t = \frac{M}{V} \quad (1)$$

$$V = \frac{M_w}{D_w} \quad (2)$$

Substitute (2) in (1):

$$D_t = \frac{M}{\frac{M_w}{D_w}} = \frac{M}{M_w} \times D_w = \text{specific gravity of tar at } t° \times \text{density water at } t°.$$

Now in experiment the following figures were determined for a tar

at	a°	D
"	(a + b)°	D_1
"	(a + 2b)°	D_2

and assuming a constant mass

at	a°	V
"	(a + b)°	V_1
"	(a + 2b)°	V_2

a° and (a+2b)° were the limits of temperature in which tar are usually measured and it was found that for all practical purposes

$$V_2 - V_1 = V_1 - V$$

or

$$\frac{V_2 - V_1}{b} = \frac{V_1 - V}{b} = \text{constant.}$$

Then if V is taken as unity the constant represents the amount 1 unit volume of tar will expand or contract for 1° change in temperature.

To illustrate the above by a practical example:—If on a tar we found

60°F. density = 1.200
100°F. " = 1.185
140°F. " = 1.170

then

60°F. 1 volume
100°F. 1,01266 "
140°F. 1,02564 "

$V_2 - V_1 = .01298$ C = .000324
$V_1 - V = .01266$ C = .000317

On writing the fifth significant figure 2 we have .00032 as the coefficient to be used in that particular tar. In practice the problem involved is to reduce a volume of tar taken at a higher temperature to 60° F.

So if

v = observed volume
t = temperature in °F.
c = coefficient of expansion
$V_{60} = V - V\,(t - 60)\,C$

In the accompanying table are shown a number of dry tars thus tested, giving free carbon, specific gravity, and coefficient of expansion.

To summarize:

1. The coefficient of expansion of tar is defined as the amount one unit volume of tar will expand or contract for one degree Fahrenheit.

2. The coefficient is practically constant for any particular tar in ordinary ranges of temperature.

3. The coefficients of expansion of a number of tars are given.

Source of tar	Free carbon, per cent.	Specific gravity at 60° F.	Coefficient of expansion for °F.
Water Gas Tar.....	1.04%	1.073	.0003750
Water Gas Tar.....	1.08%	1.090	.0003550
Gas Works Coal Tar...	16.67%	1.203	.0003125
Gas Works Coal Tar...	18.53%	1.205	.0003125
Gas Works Coal Tar...	27.50%	1.249	.0003100
Gas Works Coal Tar...	33.17%	1.296	.0002700
Coke Oven Coal Tar...	8.97%	1.185	.0003375
Coke Oven Coal Tar...	5.27%	1.193	.0003350
Coke Oven Coal Tar...	4.04%	1.178	.0003300
Coke Oven Coal Tar...	6.72%	1.195	.0003250
Coke Oven Coal Tar...	6.65%	1.197	.0003125
Coke Oven Coal Tar...	9.10%	1.203	.0003125
Coke Oven Coal Tar...	19.06%	1.258	.0003075
Coke Oven Coal Tar...	15.02%	1.231	.0003050

A New Natural Oxide. A. S. B. LITTLE. (*Progressive Age*, xxix, 101.)—The discovery is announced of a deposit of natural hydrated ferric oxide in this country similar and superior to the European deposits. It is active from the start, shows very high efficiency, and is readily revivified. Its great efficiency is due to the minute state of subdivision existing in the oxide between the ferric oxide and small quantities of silica, together with the water of hydration. It is thought that this ferric oxide may be used in suspension in water in closed vessels.

The Conservation of Wood Piles by the Injection of Zinc Fluoride. (*Génie Civil*, lviii, 465.)—Tests made by the Austrian Postal and Telegraph Bureau on treating pine, fir and spruce piles showed that acid zinc fluoride, $ZnFl_2$, was more efficacious than creosote. Dilute solutions were very quickly absorbed, variations in temperature below 50° C. having no effect. Another product for treating timber is mentioned, called "bellite," which is a mixture of sodium fluoride, dinitrophenol, and aniline.

Decomposition of Water by Zinc. M. KERNBAUM. (*Comptes Rendus*, clii, 1668.)—When zinc dust is shaken in water in the presence of air, hydrogen and hydrogen peroxide are produced, but in the absence of all traces of oxygen, the hydrogen peroxide is not formed. Hydrogen is formed whether oxygen is present or not.

Osmium as a Hardener for Platinum. ANON. (*Brass World*, vii, 230.)—Pure platinum is as soft as soft iron, and nearly all commercial platinum is hardened by adding iridium. W. C. Heraeus has found that osmium is superior to iridium for this purpose. It is stated that 2 per cent. of osmium imparts as much hardness as 5 per cent. of iridium, and a much greater elasticity. The presence of iron or copper considerably neutralizes the hardening effect of osmium. If more than 20 per cent. of osmium is present, the platinum alloy becomes brittle. The alloying must be done in a deoxidizing atmosphere, as osmium is easily oxidizable and the fumes are poisonous.

Koppers By-product Coke Ovens. W. E. HARTMAN. (*Mines Minerals*, xxxi, 185.)—The heat distribution is claimed to be better than in other types of by-product coke ovens, giving a very uniform quality of coke. The Koppers improved cross-regenerators raise the temperature of the air for combustion to 2000° F. Besides the high quality of the coke, the other claims for these coke ovens are: Economy in the use of gas for heating the ovens; the individual type of regenerator; the simplified construction and increased saving in all the by-products; and the simplicity of operation. Koppers patented direct process for the recovery of by-products is simple and more economical in operation than the older processes.

BOOK NOTICES.

THE CHEMISTS' POCKET MANUAL. A practical handbook containing tables, formulas, calculations, information, physical and analytical methods for the use of chemists, chemical engineers, assayers, metallurgists, manufacturers, and students. By Richard K. Meade, Analytical and Consulting Chemist and Chemical Engineer. xii + 443 pages, 6 x 4 inches, leather. Second edition; price, $3.00. The Chemical Publishing Company, Easton, Pa., 1910.

In commercial chemical investigation, as in other branches of industrial research, economy of labor by expeditious methods is of prime importance and a set of notes describing processes and methods is as necessary to the chemist as the "pocket-book" is to the engineer.

Here, in a condensed form, are collected a large number of tables of chemical and physical data and explicit instructions for carrying out analytical determinations. The numerous references to original sources of information with each topic of the latter are a valuable feature when occasionally more detailed descriptions are desired. Much additional matter has been introduced in re-editing the work, making it more than double its former size.

HANDBUCH DER TELEPHONIE. Nach dem Manuskripte des Dr. Victor Wietlisbach, Weiland technischer Director des Schweizer Telephonwesens in Bern bearbeitet von Dr. Robert Weber, Professor der physik an der Akademie in Neuchatel. Zweite Auflage bearbeitet von Ingenieur Johannes Zacharias. 468 pages, illustrations, 8vo. Vienna, A. Hartleben, 1910. Price, in cloth, 12 marks.

The work is devoted to the consideration of telephony as it is at present carried on in Germany. Dr. Wietlisbach, who prepared the original manuscript, was at one time director of the technical department of the Swiss telephone systems, and the first editor, Dr. Weber, was a professor of physics.

The present edition has been thoroughly revised and considerably enlarged by the German engineer, Johannes Zacharias, and shows the results of the co-operation of the engineer and physicist.

Following the historical note and the consideration of the theoretical principles of telephony, the various telephone systems and apparatus are described and illustrated. The construction and mechanical details of the installations are given full consideration and the work closes with a chapter on wireless telephony.

Students of the subject will find much interesting information, especially as regards German practice.

LA MÉTALLOGRAPHIE APPLIQUÉE AUX PRODUITS SIDÉRURIGIQUES. Par Umberts Savoia, Ingenieur, Assistant de Métallurgie à l'Institut Royal Technique Supérieur de Milan. Ouvrage traduit de l'Italien. vi + 218 pages. 7½ x 5½ inches, paper covers, with 94 figures. Price 3 francs 25. Gauthier-Villars, Paris, 1910.

As a mode of readily determining the properties of metals and their alloys beyond the reach of physical test and chemical analysis, metallography has achieved a signal success and may now be classed as an indispensable method of the modern metallurgical laboratory.

The work here presented is the result of the author's personal study under the direction of noted French authorities and his subsequent experience in organizing a metallographic laboratory in the Milanese Steel Works. The methods and results presented consequently represent recent practice recorded from actual trial. About one-third of the work is devoted to fundamentals, the apparatus best adapted to the purpose and their manipulation. The subsequent chapters deal with particular investigations of a number of different ferric alloys. The bibliography appended to each chapter is a commendable feature.

LE BLANCHIMENT, CHIMIE ET TECHNOLOGIE DES PROCÉDÉS INDUSTRIELS DE BLANCHIMENT. Par A. Chaplet, Ancien Directeur d'usines et H. Rousset, Ingénieur-Chimiste. Paper covers, 171 pages. 7½ x 4½ inches, with 10 figures. Encyclopédie scientifique des Aide-Mémoire-Gauthier-Villars, Paris, 1910.

While it is in the textile industries that bleaching processes hold seemingly the foremost place, they are of equal importance in many other industries of lesser magnitude. In a condensed form the authors have sought to collect an account of the theory and practice applied to a variety of purposes not readily available by reference to recent technological works.

The book is divided into two parts. In the first, the principles of modern industrial methods as well as the treatments applied in the processes of bleaching are discussed. The second part is devoted to the description of practical methods employed and contains detailed information of processes applied to a variety of materials. The authors have not only compiled the data presented from available literature but have included the results of their own practical experience in this field.

MEMBERSHIP NOTES.

Changes of Address.

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NECROLOGY.

Mr. William Dunlap Sargent, 51 Remsen Street, Brooklyn, N. Y., died August, 10, 1911. He was born in Ligonier, Westmoreland County, Pennsylvania, July 2, 1845, the son of Elijah and Matilda (Tannehill) Sargent, and was educated in the public schools of Harrisburg, Pa., and, at an early age, became a telegraph operator in the service of the Pennsylvania Railroad. During the Civil War he served in the United States Military Telegraph Corps at General Burnside's headquarters in Cincinnati, Ohio. Later he became the manager of the Western Union Telegraph office at Harrisburg, Pa.; Assistant Electrician of the Western Union Telegraph Company in Chicago, Ill.; General Superintendent of the American District Telegraph in Philadelphia, Pa., where he installed the system.

Mr. Sargent entered the service of the Bell Telephone Company of Philadelphia, filling the office of General Superintendent and General Manager in the development of the business. Later he went to Brooklyn, N. Y., as General Manager of the New York and New Jersey Telephone Company, and while there was selected to represent the American Bell Telephone Company and to take charge of their exhibit at the Paris Exhibition in 1889.

Mr. Sargent was a director of the National City Bank of Brooklyn and of the Brooklyn Public Library. He was a member of the American Institute of Electrical Engineers, the Institution of Electrical Engineers, the United States Military Telegraphers' Association, The Franklin Institute, the Brooklyn Institute, the Pennsylvania Society, the New England Society, the Long Island Historical Society, the Manufacturers' Association, and of numerous clubs.

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CURRENT TOPICS

Metallic Titanium. M. A. HUNTER and E. C. JONES. (*Rensselaer Polyt. Inst. Eng. and Sci. Series, No. 1.*)—Attempts to prepare pure titanium are described in detail, with a description of the properties of the metal obtained. The reduction of sodium titanifluoride by potassium yielded material containing 73.2 per cent. of titanium. A still poorer result was obtained with potassium and barium tetanifluoride. The reductions of titanium dioxide by carbon yielded a product never containing less than 4.6 per cent. of carbon. It is doubtful whether metallic titanium can be thus prepared, the product contains varying quantities of titanium carbide and monoxide. Nilson and Petersson produced titanium of 95 per cent. by reducing titanium tetrachloride with sodium. The authors obtained pure titanium by this method, taking extreme care to exclude air from the apparatus, a steel bomb with a clamped down lid. The reaction is also instantaneous when the bomb is heated to dull redness. The product gave 99.9 and 100.2 per cent. of titanium. The metal resembles polished steel. It is hard and brittle when cold, but can be easily forged at red heat. The melting point is between 1800° C. and 1850° C. Its specified gravity is 4.50.

Neon Incandescence Tubes. G. CLAUDE. (*Comptes Rendus*, clii, 1377.)—The author has devised a method for increasing the duration of incandescence of neon tubes without using an electromagnetic valve for the continuous supply of gas to the tube. In the case of tubes with very small electrodes, these volatilize rapidly, and the incandescence soon disappears. Tubes 5 metres long and 30 mm. in diameter, provided with hollow cylindrical copper electrodes, 60 mm. in length and 25 mm. in diameter, and traversed by alternating currents of 0.4 ampére, incandesced brightly for 6–8 hours. These electrodes however became heated nearly to bright redness, and a scaly deposit, resembling copper but more brittle, formed on the glass in their vicinity. This deposit, on treatment with nitric acid, yielded a gaseous residue which exhibited the spectra of hydrogen, of neon very distinctly, and that of helium very intensely; although the neon used in charging the tube was almost free from helium. This and other experiments, show that the rare gases obtained from the deposit are absorbed by the vaporized metal. Since the disappearance of the rare gases is due to the vaporisation of the electrodes, a diminution of this vaporisation will give a longer incandescence, and this can be brought about by the use of very

large electrodes. With a tube 6 metres long, fitted with electrodes presenting a surface corresponding to 5 square dcm. per ampere, a period of incandescence of 400 hours was attained.

A Prize for a New Electric Lamp for Miners. (*Times*, London, May 27, 1911.)—The Secretary of State for the Home Department announces that to encourage the production of safe and efficient types of electric lamps for miners, a colliery proprietor has placed a sum of £1,000 at his disposal, as a prize for the best lamp or lamps fulfilling the requirements specified below. Mr. Charles Rhodes, a former President of the Institute of Mining Engineers, and Mr. Charles H. Merz, a member of the Departmental Committee on the Use of Electricity in Mines, have consented to act as judges. The conditions are as follows: 1. The competition is open to persons of any nationality. 2. It will be in the discretion of the judges to award the whole of the prize to the lamp they consider the best, or to divide the prize, or to make no award if no lamp appears to be of sufficient merit. 3. Lamps must be addressed, care of C. Rhodes, Esq., at the Home Office Testing Station, Rotherdam (Eng.), and must reach the testing station not later than December 31, 1911. A spare globe should accompany each lamp. The requirements are as follows: 1. The lamp should be of sound mechanical construction so as to withstand rough usage. 2. The lamp should be of simple construction and easy to maintain in good order and repair. 3. The lamp should be so constructed as to render impossible the ignition of inflammable gas either within or without the lamp. 4. The lamp battery should be so constructed that any liquid which it may contain cannot be spilled while the lamp is in use, and means should be provided for dealing with any gas which may be generated by the battery. 5. The materials used and the construction should be such that metals and other parts will not be liable to deterioration by corrosion as a result of the action of the electrolyte, etc., used in the battery. 6. The lamp should be effectively locked, so that it cannot be opened without detection. 7. The lamp should be capable of giving an amount of light of not less than 2-candle power continuously for a period of not less than 10 hours. 8. The light should be well distributed outside the lamp. A movable reflector to concentrate or shield the light may be provided. In addition to the above, regard will be paid to (a) the first cost of the lamp; (b) the cost of maintenance; (c) convenience in handling, and (d) the weight of the lamp when charged and ready for use.

Vanadium in Cast Iron. GEO. L. NORRIS. (*Iron Age*, lxxxvii, 1398.)—This is an interesting article. The chief points are: the primary purpose of adding vanadium to cast iron is not only the removal of oxygen and nitrogen, which it effects, but to increase the

strength of the cast iron to which it is added from 10 to 25 per cent., depending on the initial strength of the iron. It causes a more even distribution of the graphite, with consequent greater freedom from both hard and porous spots, thus giving a finer and more uniform grain. In chilled iron vanadium produces a deeper, stronger and tougher chill, which is less liable to spall or flake. This chill is not so hard as the more brittle ordinary chill, and can be filed and machined more readily. Vanadium also toughens the iron and makes a superior cast iron. The usual amount of vanadium added to cast iron is 1/10 of 1 per cent. for cupola melted iron, or about 5 oz. of ferro-vanadium for each 100 lbs. Some foundries advocate a higher percentage, up to 15 per cent. For higher grade air furnace iron the addition of 0.18 to 0.20 per cent. of vanadium is recommended.

Washing Oils for the Removal of Naphthalene from Coal Gas. A. BAYER. (*J. Gasbeleucht*, liv, 496.)—For the removal of naphthalene from coal gas the author uses a light oil of the following composition: Benzene 0.4. light oil (100°–180°C.) 67.6, middle oil (180°–230°C.) 25.0, naphthalene 3.9, and heavy oil 3.1 per cent. This thoroughly removes the naphthalene and imparts light and middle oil to the gas, which seem to assist in the removal of naphthalene, which may have got into the mains. The naphthalene is found dissolved in the condensed hydrocarbons at various points in the system. Light oil gives much better results than heavy oil or than a mixture of heavy and middle oil.

Titanium in Iron and Steel. CHAS. V. SLOCUM. (*Amer. Mach.*, xxxiv, 1165.)—This interesting paper is worth perusal and may be summarized as follows: Small percentages of titanium will successfully produce many of the benefits of a large quantity. For instance, the use of two-tenths of 1 per cent. of alloy, containing 10 per cent. of titanium, that is, the use of 0.02 per cent. of metallic titanium, is frequently sufficient to clean the iron of the impurities remaining in the metal after the ordinary fluxes have accomplished all they can. Titanium removes the oxides and nitrides from molten iron, increases the fluidity, and makes the metal more homogeneous, so that the castings are closer grained, free from pin-holes and gas bubbles, and the iron has a denser structure and is easily machined. 0.1 to 0.2 per cent. of the alloy is sufficient to make viscous high-chilling mixtures come from the cupola close-grained and pour freely. The cost of the titanium is compensated by the use of less manganese and a trifle less silicon. The expense runs from 25c. per ton of castings up to say $3 as a maximum, which is often repaid in the reduction of bad work and in the improvement of poor irons. The same holds good for steel castings. One great advantage of the regular use of the titanium

alloy is that it removes those features of irregularity which have given steel a bad name for its unreliability in certain directions. In a recent trial of the alloy in basic open-hearth by one of the large steel makers, it was found that 1½ per cent. of alloy was necessary to remove the last vestiges of brittleness and of blow holes, and this made the steel so dense that it was unusually strong, and became the source of much comment and investigation.

Alloys for Permanent Magnets. ANON. (*Amer. Machinist*, xxxiv, 1075.)—The addition of chromium to pure iron without carbon does not give good results, according to *Génie Civil*. An alloy containing 5 to 6 per cent. of chromium with 0.75 to 1 per cent. of silicon and 0.3 to 0.5 per cent. of carbon is excellent. An alloy containing 8 per cent. of molybdenum, 0.3 per cent. of vanadium and 0.6 per cent. of carbon makes good permanent magnets, which preserve their magnetic properties above 1000° C. Alloys of tungsten and iron are useless, except one which contains 4 per cent. of tungsten and 0.4 per cent. of vanadium; this makes an excellent permanent magnet.

Steam-boiler Economics. *Edit.* (*Eng. Record*, lxiii, 689.)—Mr. Geo. H. Barrus reviewed the results of 30 years' experience in steam-boiler testing, in a paper read before the Congress of Technology at Boston, Mass. This is a paper worthy the attention of steam-users. Its main points may be recommended thus: The economy resulting from the admission of air over the fuel bed, in a boiler of the horizontal return tubular type, is stated to be such that the evaporation per pound of combustible was increased 10 per cent., from 10.23 to 11.35 lbs. from and at 212° F.; the draft between damper and boiler being about 0.3 inch, and the temperature of the escaping gases was 510° F. with air admission, and 515° F. without it. The disadvantages of a thick fuel were clearly shown. With a fire-thickness of 12 inches the percentage of carbon monoxide in the gases was 1.1 compared with 0.1 with a 6 inch fire, and the evaporation was 11.5 lbs. with the thicker fire and 12 lbs. with the thinner. The importance of a clean heating surface is clearly shown. Incomplete combustion is often responsible for relatively low efficiency. Forcing the output reduces the efficiency. Interior scale and neglect in maintenance also result in low evaporation.

To Prevent Dusting of Concrete Floors. ALBERT MOYER. (*Eng. Record*, lxiv, 16.)—After washing thoroughly with clean water, and scrubbing with a stiff broom or scrubbing brush, allow the surface to dry and apply a solution of one part water glass (sodium silicate), 40° Beaumé, and 3 to 4 parts water, the proportion of water depending upon the porosity of the concrete in the floor surface to be treated.

Travel of Particles in Electric Field. G. REBOUL and E. G. DE BOLLEMONT. (*Comptes Rend.*, clii, 758.)—If copper and platinum electrodes, separated by mica, are heated, a deposit of copper oxide is found on the platinum. Its contour is similar to that of the copper, so that the particles are projected across. The amount of deposit reaches a maximum in a time ranging from 30 minutes at 400° C. or above to 30 seconds at 900° C. Thereafter the deposit continually disappears. The distance between the electrodes must be under 3 mm.; within this limit the smaller the distance the greater the deposit. The condition of the surfaces has considerable effect on the results.

Ionisation of Gases by Light Emitted from Geissler Tubes. H. G. CONNEGIETER. (*Konink. Akad. Wetersch, Proc.*, xiii, 1114.)—If it is considered that the action of ether vibrations upon the molecules of substances is a resonance effect, then if molecules on which the light shines are struck by vibrations the period of which corresponds to those which the electrons in molecules can emit themselves under certain conditions, the electrons will acquire by resonance so strong a motion that they are loosened from the molecule and behave like free particles. From this point of view it may be expected that if a given substance in the luminous state emits electrically active rays, this substance, when struck by these particular rays will be more photo-electric than when under the influence of rays from any other source of light. The apparatus used in the experiments consisted of three parts: (a) the discharge tube, (b) the absorption space, and (c) the ionisation chamber, all of which are air tight, and can be filled with any desired gas. By this arrangement it is possible to examine the absorption of different gases for the ionising rays, and to study the connection between absorption and ionisation. The effects caused by hydrogen, nitrogen, and carbon monoxide radiation are dependent on the pressure of the gas; the mutual proportion of the effect on the different gases varies with the pressure of the gas. The values of this proportion show that when the pressure is high the ionisation is always strongest in hydrogen, then in carbon monoxide, nitrogen, air and oxygen in order. The proportion changes when the pressure in the gas is lowered.

The Rays of the Alkaline Metals. E. HANRIOT. (*Moniteur Scient.*, 834, 410.)—Potassium salts have a very penetrating ionising radiation; the radiation of the rubidium salts is less penetrating, but more intense; on the other hand the cœsium salts have never shown any appreciable ionisation, which is very unexpected considering the close relationship of these three metals. It is natural to ask if the electrons emitted with such high speed by potassium, and with a lower speed by rubidium, are not also emitted by cœsium, but with an energy insufficient to produce ionisation. Experiments have been made in this direction by means of a

charged electroscope, placed above a layer of a salt of one or other of these three metals; when the electroscope was positively charged, it gave an appreciable deflection with potassium or rubidium salts, but no deflection or at best only doubtful, with cœsium salts.

Water Softening by Aluminum Plates. T. R. DUGGAN. (*Eng.* cxi, 392.)—This method was discovered by Brandes and is known as the "Luminator" process. The water is allowed to run down an aluminum plate of special dimensions, with corrugations of a particular size, according to the character of the water under treatment. No chemicals are used; all that is required is to keep the corrugations well brushed and clean from the deposit. When the storage tanks and mains are far from the boiler, they should be coated with a non-conducting composition, and the water should reach the boiler as soon after treatment as possible. Storage tanks should not be too large, as the water should be used within seven days after treatment to get the maximum effect. When water is passing continuously, day and night, it may be necessary to give the apparatus a rest about one day per week to avoid polarisation of the plates. The passage of the water over the channels at certain speeds induces a current of electricity, the water being negative and the plates positive, and the salts are ionised, and assume the amorphous instead of the crystalline form. At the same time the aluminum, through friction and the electrical action, is abraded from the surface as a colloid, which undergoes change in the water. F. G. Donnan found but little aluminum hydroxide in the treated water, but the ultra-microscope showed colloidal aluminum mixed with hydroxide. Water thus treated deposits much less scale; old scale is softened and detached from the plates, especially the flues; steam is drier; less coal is needed for steam-raising, and the salts are found as powder in the bottom of the boiler. It is important that boilers should be regularly blown off, particularly when the apparatus is first installed, as the old scale comes down so rapidly that the plates may become overheated from its accumulation, unless it is quickly removed. After the old scale is removed, this danger ceases, as only mud is found in the boiler, and the water is in contact with the plates and tubes. If the boiler is systematically blown off, little or no mud will be found in it. Priming is much less, or quite eliminated, by the use of this apparatus.

Bronze and Iron Articles of the La Tene Period. H. RUPE. *Verh. Naturf. Ges. Basel*, xxi, 40.)—Bronze and iron particles from the graves of Tessin were examined. About 11 per cent. of the bronzes examined contain 90 per cent. copper and 10 per cent. tin. About 5 per cent. contain only 1.5 per cent. of tin or less, which indicates they were made from a copper ore containing tin. The analysis of the iron articles leads to the following deductions

as to their origin, age and workmanship. Irons with high phosphorus or sulphur were found in the territory of the present Switzerland; those with low P and S were probably imported from Etruria. The photographs of etchings from prehistoric iron lead to the inferences that the iron of the La Tène period was not completely fused.

Aluminum Windings for the Field Magnets of Traction Motors. A. MARIAGE. (*Lumière, Electr.*, xiv, 104.)—Experiments are being made with aluminum instead of copper conductors on the field magnets of motors for traction purposes. The advantages of aluminum are its lightness and cheapness; the economy is about 60 per cent. The cost of renewals is less than that with copper, and the effects of vibration are not so marked. The disadvantages are the cost of soldering and the greater bulk.

Production and Uses of Zinc Dust. P. SPEIER. (*Mining Sci.*, lxiii, 38.)—Zinc dust is obtained in the reduction of spelter by means of special collectors. The quantity of zinc dust recovered in proportion to the production of spelter depends on the furnace charge as well as on the temperature of the distillating furnaces, and may become as high as 10 to 15 per cent. of the spelter produced. To be merchantable it must contain about 90 per cent. of zinc. It is used for various purposes in the industries, e. g., for reducing indigo blue and nitro-benzene, for purifying fats, for bleaching glue, in the Cowper-Coles galvanizing process, for the extraction of gold in the cyanide process, and so on. Drewsen's method is recommended for the analysis of zinc duct, which is based on the power of finely divided zinc to reduce a solution of chromic acid without generating hydrogen.

Effect of the Dust of Tarred Roads on the Eyes. L. PHILIBERT. (*Rev. Gen. Sci.*, xxii, 207.)—Ordinary calcareous or siliceous road dust causes only a slight inflammation. That from tarred roads causes chronic inflammation and conjunctivitis. This is chiefly due to the carbolic and phenolic vapors of freshly laid tar. Oil is proposed as a substitute.

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